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Anaesthesia

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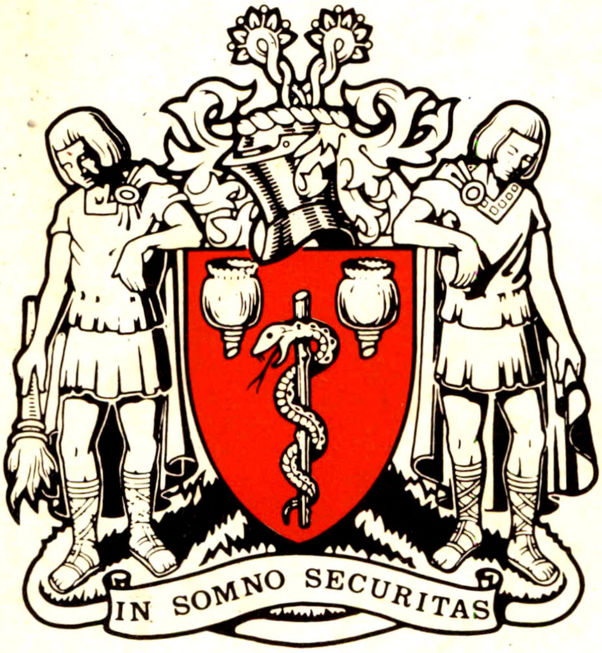

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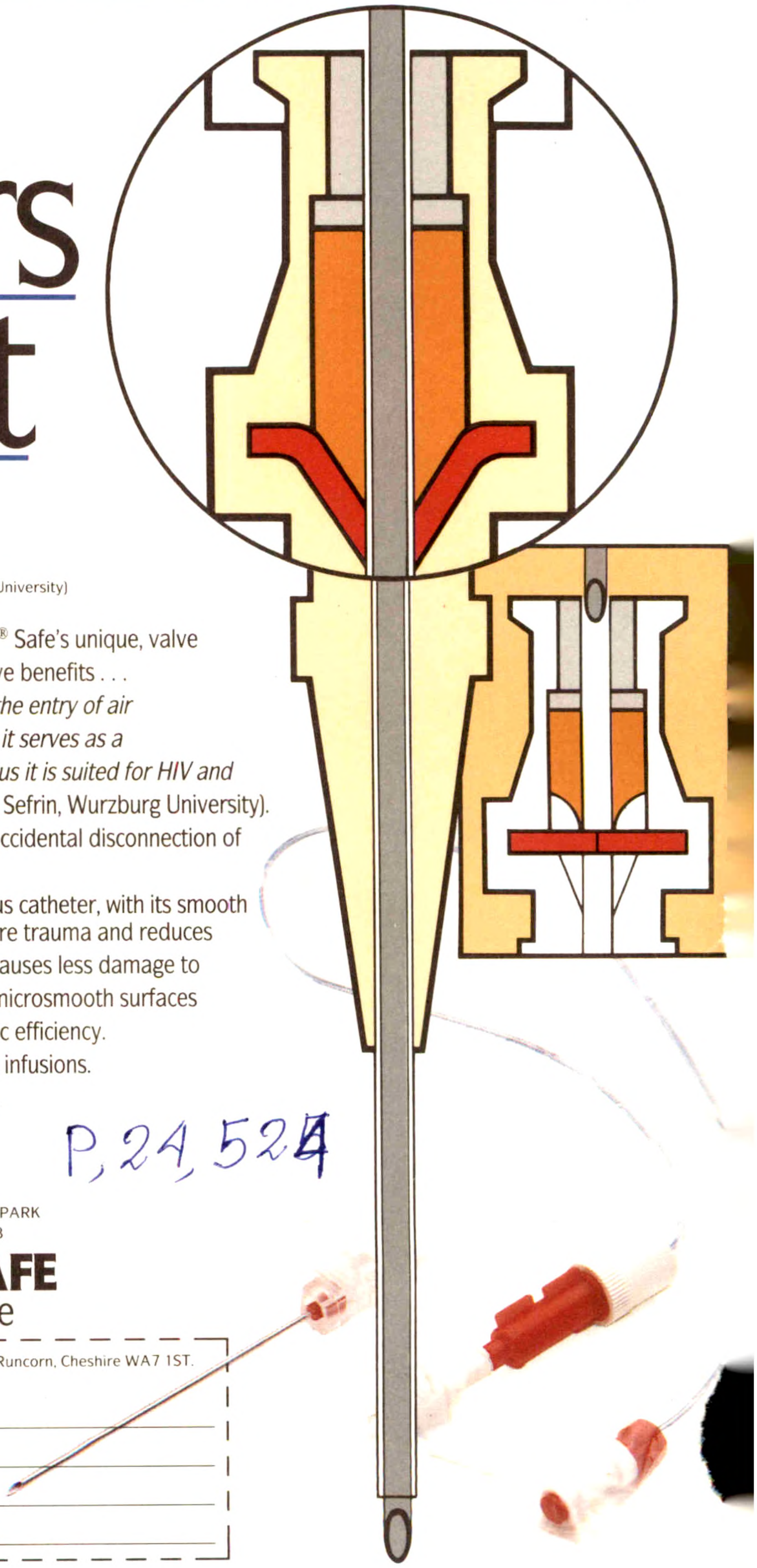

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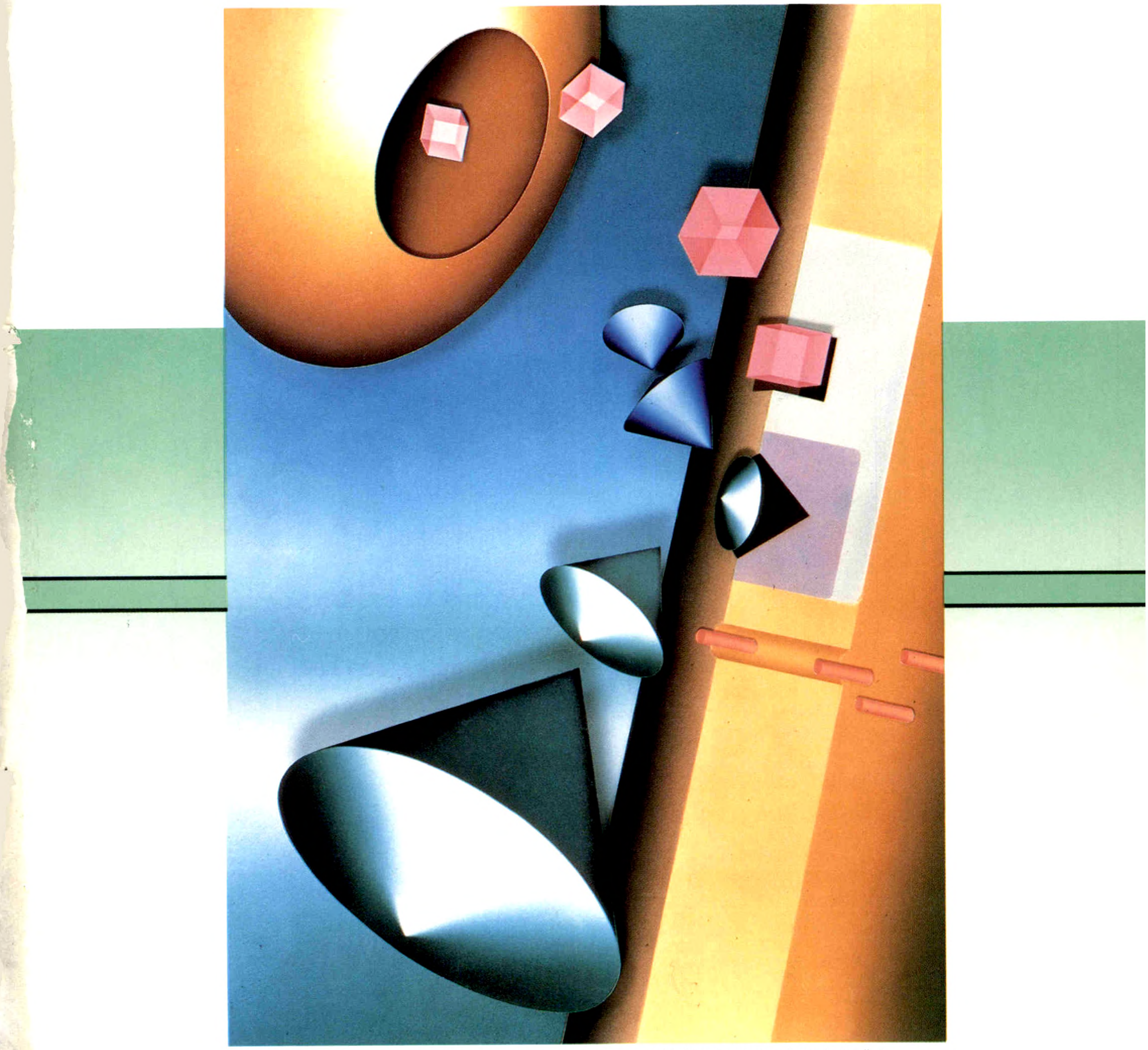

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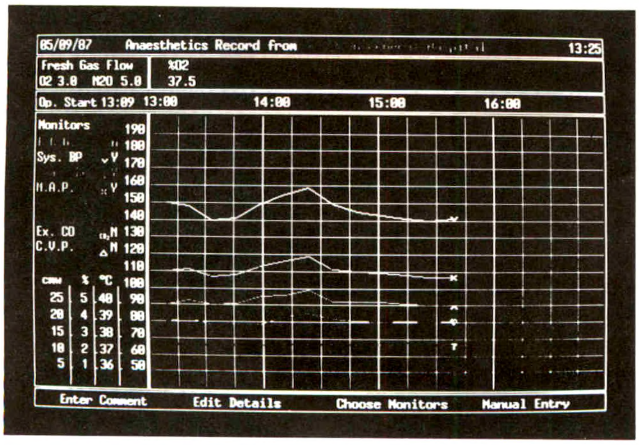

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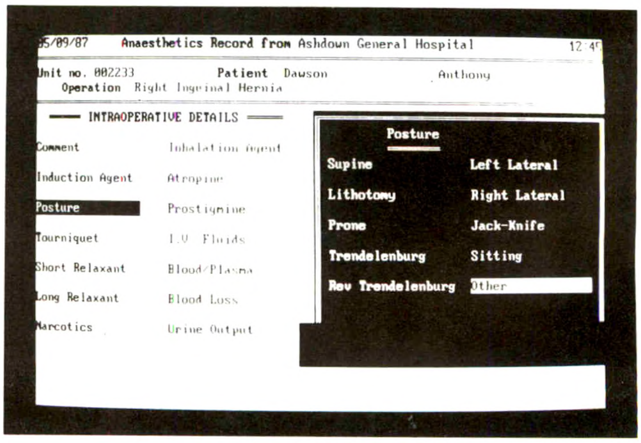

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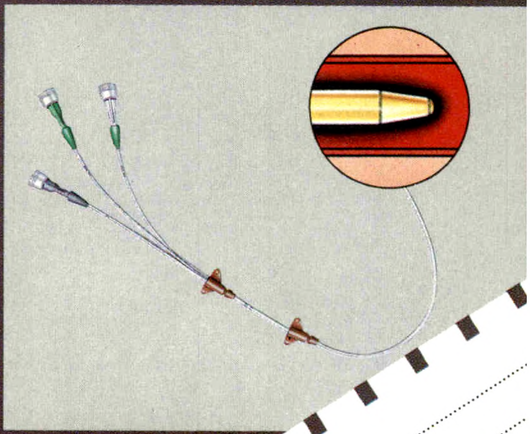

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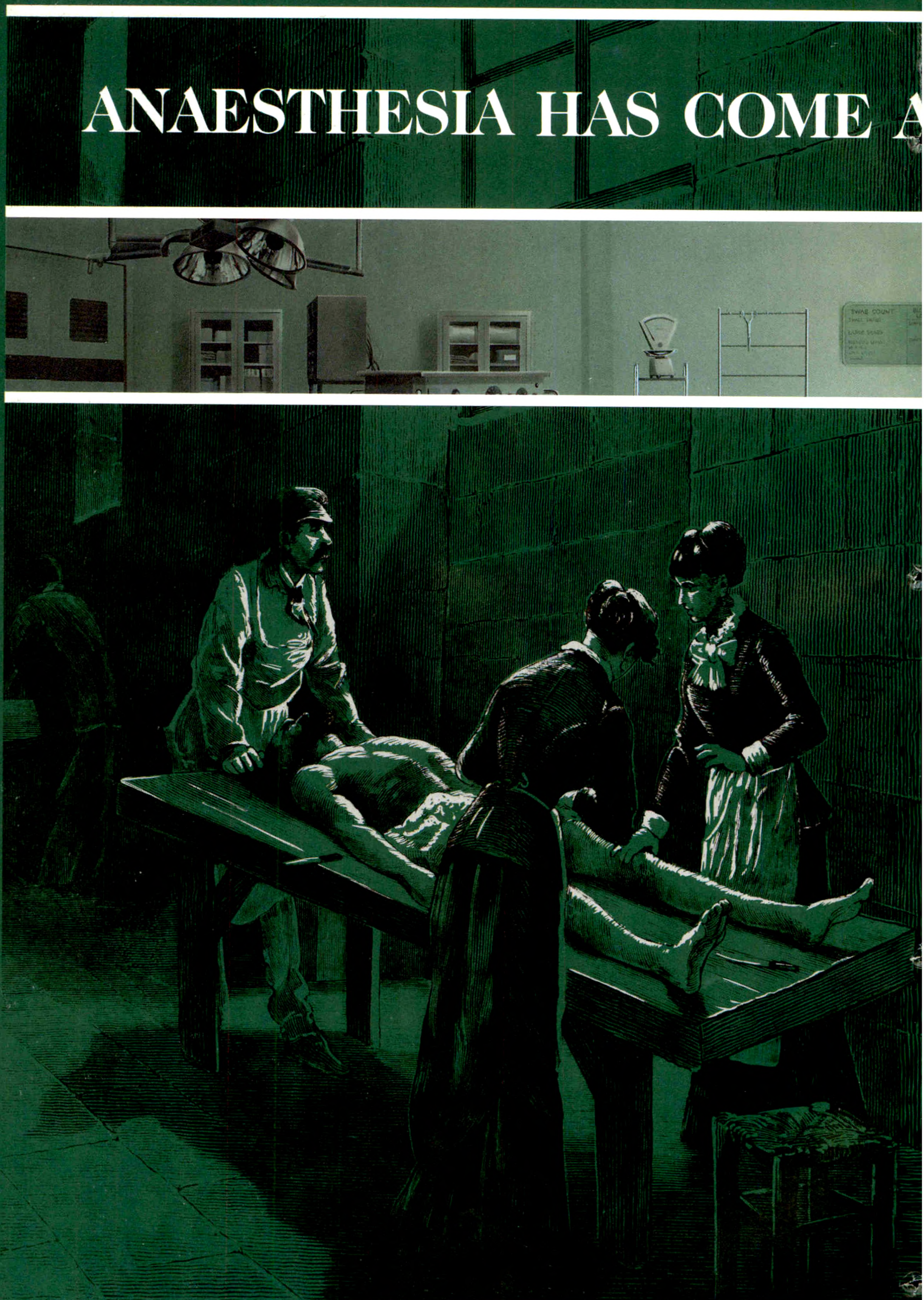

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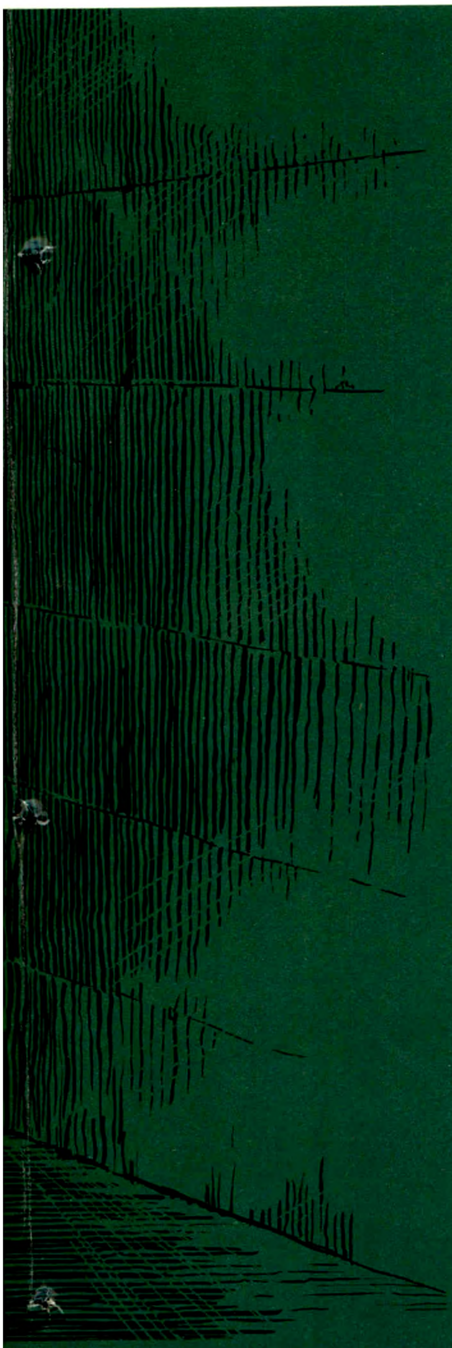

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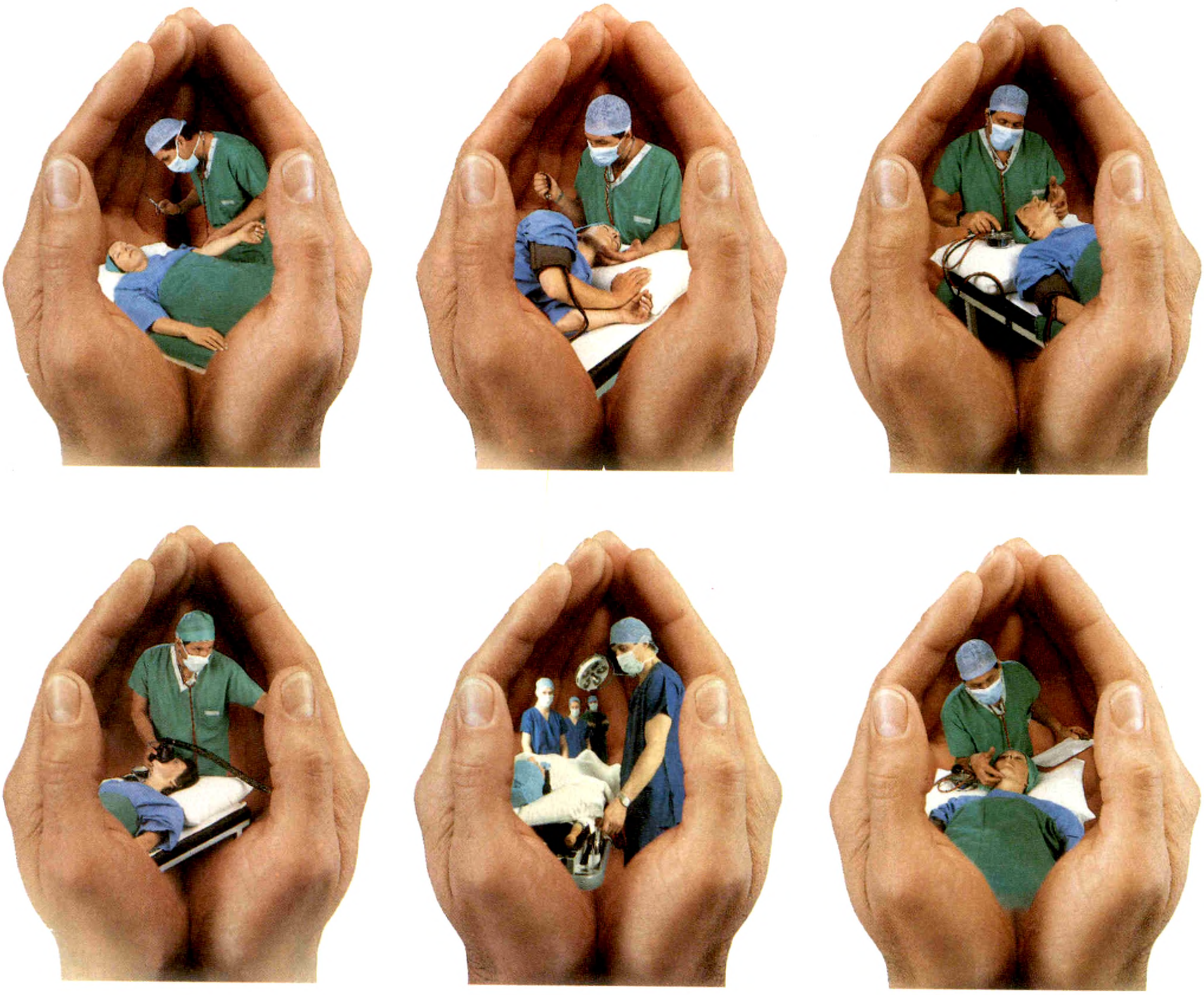

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Anaesthesia, 1988, Volume 43, pages 531–532

Editorial

Diabetes and anaesthesia—slow progress?

It is now nearly 10 years since Alberti and Thomas proposed the use of a continuous glucose–insulin–potassium (GIK) infusion for the management of insulin-dependent diabetic (IDD) patients who undergo surgery.[1] A recent survey of the peri-operative management of diabetic patients in the Oxford Region published in this issue of the Journal, (page 538) shows that the infusion regimen has been widely adopted, especially by junior anaesthetists. Noninsulin-dependent diabetic (NIDD) patients who underwent minor or intermediate surgery were managed by nearly all anaesthetists simply by omitting food and oral hypoglycaemic agents. In those NIDD patients who underwent major surgery 88% of senior house officers indicated that they would use a GIK infusion compared with only 41% of consultant staff. In IDD patients who had intermediate or major surgery junior staff preferred the GIK regimen. Consultant staff on the other hand, were divided between the infusion technique and a regimen using a proportion of the patient's usual insulin dose and intravenous glucose. This survey shows that the GIK technique has achieved widespread popularity particularly amongst junior anaesthetists. Is this popularity based on good evidence?

Several years elapsed after the GIK regimen was first proposed before supporting data was published in the anaesthetic literature.[2] The results were unimpressive and showed only a transient improvement in glycaemic control in IDD patients managed with the GIK regimen compared with a conventional technique (proportion of usual insulin plus intravenous glucose). Furthermore, the study was criticised for the failure to standardise the surgical stimulus, anaesthetic technique and intravenous infusions, factors all known to influence the hormonal and metabolic response to surgery.[3]

Alberti's group have continued to investigate the use of the GIK technique in NIDD patients who undergo transurethral resection of the prostate.[4] They compared normal patients with NIDD patients managed either by GIK infusion or simply by the omission of the hypoglycaemic agents (no insulin). Not surprisingly, blood glucose values were significantly increased in both groups of NIDD patients compared with normal patients throughout the study. However, the GIK infusion resulted in a significant decrease in blood glucose compared with the no insulin group only at 2 hours postoperatively. Furthermore, in the NIDD patients managed with no insulin the circulating metabolites and insulin values were closer to the normal patients than in those diabetics treated with GIK. The authors concluded that in NIDD the GIK regimen, rather than making the metabolic state normal, *produced fresh abnormalities.*

This issue of the Journal also contains a report (page 533) of the management of IDD patients undergoing minor surgery, either by the infusion regimen or by conventional subcutaneous insulin together with intravenous glucose. In this instance premedication, anaesthetic technique and postoperative analgesia were all standardised. The use of the GIK regimen was associated with a lower blood glucose during and after the infusion period but for all other metabolites and hormones, there were no significant differences between the two methods of management. The data presented, however, suggest that those patients treated with the conventional regimen were inadequately controlled on admission to the study with blood glucose values in the range 8–25 mmol/litre. The median glucose was still 4 mmol/litre higher in the conventional group at 0700 hours on the day of surgery, although this difference was not significant. The suspicion that pre-operative glycaemic control was better in the GIK group is supported by the lower glycosylated haemoglobin values.

The M-value was calculated for each patient on the day of surgery as part of the comparison of the two treatements. It was described by Schlichtkrull and colleagues[5] in 1965 as a quantitative index of blood glucose control in individual patients, and was designed as a numerical substitute for the clinical assessment of diabetic therapy. The M-value is calculated by a simple formula applied to the blood glucose values obtained from the patient during each day. M is zero in normal patients and the values become higher the worse the glycaemic control in diabetic patients. It is interesting to note that in the current study by Christiansen and colleagues, the median M-value in the GIK group was 15.8 compared with 25.9 in the patients treated conventionally. This difference was not statistically significant.

A recent report has documented the use of the GIK regimen under routine clinical conditions for both IDD and NIDD patients.[6] All IDD patients were managed with the infusion technique as were NIDD patients who underwent major surgery or with poor glycaemic control. NIDD patients who underwent minor surgery were managed without insulin. Acceptable glycaemic control (mean blood glucose of 5–12 mmol/litre) was achieved in 86% of all operations and in 82% of those having the GIK regimen. There were seven instances of clinical or biochemical hypoglycaemia (blood glucose <3 mmol/litre). Twelve cases of persistent hyperglycaemia occurred and the failure to achieve adequate control of blood glucose was ascribed to deviation from the protocol. The results of this study show that the GIK infusion technique produces acceptable blood glucose values in most diabetic patients but no other insulin regimen was used for comparative purposes.

A vital aspect of the management of any diabetic patient in the peri-operative period is the accuracy of blood glucose monitoring. Blood glucose is commonly measured in the operating theatre with reagent strips and reflectance meters. Prompt results are obtained which enable rapid alterations of the infusion regimen to be made if necessary. However, caution must be exercised in the interpretation of the results obtained in this way. Accuracy is reduced when blood glucose meters are used outside the hospital laboratory, and in some instances 30% of results varied by more than 20% of the laboratory value.[7] Inaccuracy may result from variations in the size of the blood sample placed on the regeant strip, the timing and washing of strips and failure to clean the calibration chips. It is *imperative* that systems used for measurement of glucose units are

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subjected to frequent and rigorous quality control assessments. Only then can the assertion in the Oxford survey that a reliable estimation of blood glucose concentration is easily obtained, be substantiated.

The primary objective of most anaesthetists who manage diabetic patients is good control of the blood glucose concentration, the avoidance of hypoglycaemia and excessive hyperglycaemia. It has been considered by most authorities that diabetic patients are at an increased risk of postoperative complications and that avoidance of severe hyperglycaemia may reduce this risk. Much of the work cited to support this viewpoint is mainly of historical interest but is still quoted by many authors. Thus the publication of a retrospective study in 1985[8] in which 224 diabetic patients were matched for age, sex, weight, operation and pre-existing cardiovascular disease with a group of nondiabetic patients is of considerable importance. There was no difference in the incidence of complications between the diabetic and nondiabetic patients. The incidence of morbidity was similar in diabetic patients treated with insulin or oral agents and diet. In addition, and of great interest, diabetic patients with peri-operative complications had *lower* blood glucose values than those without complications. The results of this study thus suggest that diabetic patients do not have an increased operative risk and casts doubt upon the role of hyperglycaemia as a causative factor in the genesis of postoperative complications. Do we need to control blood glucose so rigorously in diabetic patients?

In conclusion, there is an urgent need for further studies to compare different regimens for the management of diabetic patients in the peri-operative period. In NIDD patients the GIK regimen seems to be of little value in minor and intermediate surgery, but should be considered for major surgery and in those patients with inadequate glycaemic control. The evidence that any benefit accrues from the GIK infusion in IDD patients compared with other conventional techniques is virtually nonexistent. We accept that it is logical, simple and provides good glycaemic control in most patients, but where are the controlled, comparative studies?

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References

1. ALBERTI KGMM, THOMAS DJB. The management of diabetes during surgery. *British Journal of Anaesthesia* 1979; **51:** 693–710.
2. THOMAS DJB, PLATT HS, ALBERTI KGMM. Insulin dependent diabetes during the peri-operative period. An assessment of continuous glucose–insulin–potassium infusion, and traditional treatment. *Anaesthesia* 1984; **39:** 629–37.
3. HALL GM. Diabetes and anaesthesia—a promise unfulfilled? *Anaesthesia* 1984; **39:** 627–8.
4. THOMPSON J, HUSBAND DJ, THAI AC, ALBERTI KGMM. Metabolic changes in the non-insulin dependent diabetic undergoing minor surgery: effect of glucose–insulin–potassium infusion. *British Journal of Surgery* 1986; **73:** 301–4.
5. SCHLICHTKRULL J, MUNCK O, JERSILD M. The M-value, an index of blood sugar control in diabetics. *Acta Medica Scandinavica* 1965; **177:** 95–102.
6. HUSBAND DJ, THAI AC, ALBERTI KGMM. Management of diabetes during surgery with glucose–insulin–potassium infusion. *Diabetic Medicine* 1986; **3:** 69–74.
7. BURRIN JM, WILLIAMS DRR, PRICE CP. Performance of a quality assessment scheme for blood glucose meters in general practice. *Annals of Clinical Biochemistry.* 1985; **22:** 148–51.
8. HJORTRUP A, SORENSEN C, DYREMOSE E, HJORTSO NC, KEHLET H. Influence of diabetes mellitus an operative risk. *British Journal of Surgery*, 1985; **72:** 783–5.

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Anaesthesia News

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Anaesthesia, 1988, Volume 43, pages 533–537

Insulin treatment of the insulin-dependent diabetic patient undergoing minor surgery

Continuous intravenous infusion compared with subcutaneous administration

C. L. CHRISTIANSEN, B. A. SCHURIZEK, B. MALLING, L. KNUDSEN,
K. G. M. M. ALBERTI AND K. HERMANSEN

Summary

In a prospective randomised study in 20 insulin-dependent diabetics who had minor surgery under general anaesthesia we compared the metabolic responses to intravenous glucose–insulin–potassium infusion with those who had conventional subcutaneous insulin administration. The former treatment resulted in lower blood glucose levels both during the infusion period ($p < 0.05$) as well as the entire observation period (operative, first and second postoperative days; $p < 0.01$). More blood glucose values were within the intended range of 5 to 10 mmol/litre in the glucose–insulin–potassium as compared to the conventional group (48% versus 24%; $p < 0.01$). The levels of lactate, 3-hydroxybutyrate, glycerol, alanine, glucagon, insulin and growth hormone did not differ between the two groups. The infusion regimen resulted in better glycaemic control both peri-and postoperatively than the conventional subcutaneous insulin regimen in insulin-dependent diabetic patients who have minor surgery.

Key words

Complications; diabetes mellitus.
Hormones; insulin.

Anaesthesia and surgery constitute a significant metabolic and clinical stress to diabetic patients. It is important to control glycaemia well since poor metabolic control is associated with susceptibility to infection[1] and impaired wound healing[2]. The treatment of insulin-dependent diabetic patients during anaesthesia and surgery has been subject to different regimens. Conventional practice is to give insulin subcutaneously pre-operatively (0.5–0.66 × usual daily dose) and to supplement it postoperatively.[3] A more recent regimen provides a continuous infusion of a mixture of glucose, insulin and potassium (GIK).[4] Little is known about the influence of the two regimens on the hormonal and metabolic perturbations to minor surgery (that is surgery which does not involve penetration of a body cavity or transection of a major limb bone).[3] In a prospective randomised study we have compared the effects of GIK and conventional treatment on the profiles of blood glucose, electrolytes, metabolic and hormonal parameters in insulin-dependent diabetics subjected to minor surgery.

Methods

The study was approved by the local ethics committee and all patients gave informed consent. During 12 months all insulin-dependent diabetic patients admitted for minor surgery, such as vitrectomy or minor hand surgery, were considered and allocated randomly to either the conventional or the GIK regimens. Patients treated with steroids or ß-adrenoceptor-blocking agents, and patients with blood glucose levels above 15 mmol/litre at 0700 on the day of operation, were not included in the study. The investigation comprised 20 patients aged 25–76 years. Nine patients in each group had vitrectomy and one patient in each group had minor hand surgery.

Diabetic management

Ten insulin-dependent diabetic patients were treated with the conventional regimen. They received half of the usual daily insulin dose subcutaneously as insulin Insulatard (Nordisk Insulin, Copenhagen, DK), if the blood glucose was ≤8 mmol/litre, and two thirds of the usual daily dose if it was >8 and ≤15 mmol/litre at 0700 on the day of operation. At the same time an infusion of glucose 55 g/litre at a rate of 100 ml/hour was instituted. To ensure a constant infusion rate a Dial-A-Flo solution set (Abott Laboratories, Vedbæk, DK) was used.

Ten subjects were treated with the GIK regimen. At 0700

C.L. Christiansen, MD, B.A. Schurizek, MD, B. Malling, MD, L. Knudsen, MD, Department of Anaesthesiology, University Hospital, Aarhus, Denmark, K.G.M.M. Alberti, FRCP, University Department of Medicine, Royal Victoria Infirmary, Newcastle upon Tyne, UK, and K. Hermansen, MD, Second Clinic of Internal Medicine, University Hospital, Aarhus, Denmark.

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on the day of the operation an infusion of glucose 55 g/litre and potassium chloride 20 mmol/litre which contained insulin Velosulin (Nordisk Insulin, Copenhagen, DK) was instituted. The amount of insulin Velosulin added per litre was 8 units if the blood sugar was $\leqslant 4$ mmol/litre, 16 units if it was 4.1–6.9 mmol/litre, 24 units if it was 7.0–11.9 mmol/litre and 32 units if 12.0–15.0 mmol/litre. The infusion sets were made of plastic (polypropylene) and the infusion rate was 100 ml/hour (Dial-A-Flo).

Infusions were maintained for 24 hours in both groups. The patients were allowed to eat postoperatively when they wanted to. The aim was to maintain the blood glucose between 5–10 mmol/litre. If the blood glucose exceeded 15 mmol/litre, 12 units of insulin Velosulin was given subcutaneously and the blood sugar measured 3 hours later.

Investigations of metabolism

The initial blood glucose was measured between 1100 and 1800 on the day of admission and thereafter strictly at 0700, 1130, 1700 and 2100 on the day of operation and on the first and second postoperative day respectively. This was carried out with Haemoglucotest 1–44 read on Reflolux (both Boehringer, Mannheim, FFG). Further blood glucose measurements were made immediately after operation and 4 hours later. The precision and accuracy of the reflectometric reading of blood glucose has been reported as excellent when estimated immediately.[5] Freely flowing venous blood samples were taken on the day of admission for estimation of metabolism, at 0700 on the day of operation, immediately postoperation and 4 hours later. Further samples were taken at 0700 on the first and second postoperative days. Lactate, 3-hydroxybutyrate, glycerol and alanine were measured using enzymatic methods.[6] Free insulin in serum was determined as described by Nakagawa[7] with modifications.[8] Glucagon and growth hormone were measured by sensitive radio-immunoassays.[9] Glycosylated haemoglobin concentration (HbA_{1C}) was measured by agar gel electrophoresis after dialysis against nine volumes of saline to remove labile adducts.[10]

Blood samples for measurements of haemoglobin, serum sodium, serum potassium, blood urea nitrogen and serum creatinine were obtained with the metabolic blood samples and estimated by standard methods in the routine clinical chemical laboratory. Changes in white blood cell counts, chest X rays and urine cultures were used as an index of infection. These parameters were investigated preoperatively and on the second postoperative day; 24-hour urine collections were estimated for glucose, ketones and potassium on the operative, and on the first and second postoperative day.

Anaesthesia

The patients were premedicated with diazepam 10–15 mg according to weight and age. Anaesthesia was induced with thiopentone, pethidine and atropine. Tracheal intubation was facilitated with suxamethonium and anaesthesia was maintained with thiopentone, pethidine and $N_2O/O_2(2:1)$. Muscle relaxation was obtained with alcuronium and neuromuscular blockade was reversed with neostigmine/atropine. The patients received an infusion of saline 0.88% together with GIK or glucose during the operation. The patients received dextropropoxyphene and later acetaminophen for postoperative analgesia.

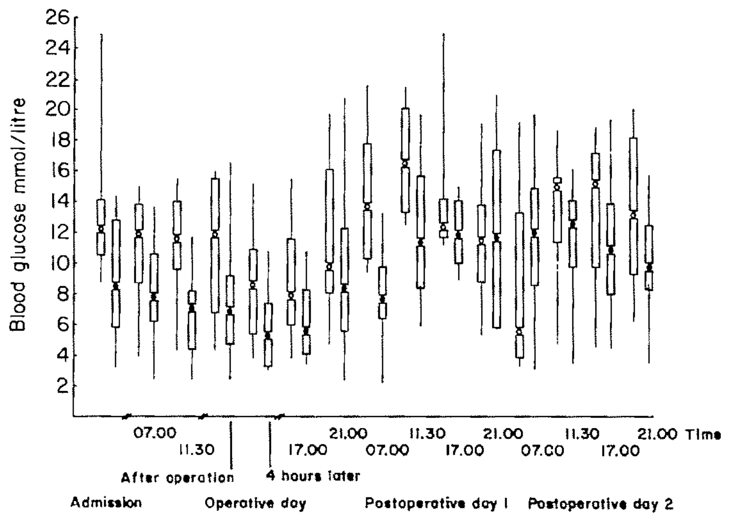

Fig. 1. The profile of blood glucose shown as mean, 25 to 75 quantile and range. GIK group ▨ • ▨, conventional group □ • □.

Table 1. Characteristics of the diabetic patients in the GIK and conventional groups expressed as median with (range).

	Sex ratio	Age, years	BMI, kg/m²	Usual insulin dose, units/day	HbA_{1C} %	Duration of fasting, hours	Length of admission, days
GIK	4/6	52 (25–74)	22 (20–31)	44 (33–76)	8.0 (7.5–9.0)	10 (8–14)	5 (1–10)
Conventional	4/6	52 (29–76)	25 (21–42)	40 (36–64)	8.8 (7.7–9.2)	10 (8–13)	5 (2–7)

BMI, body mass index; HbA_{1C}, glycosylated haemoglobin.

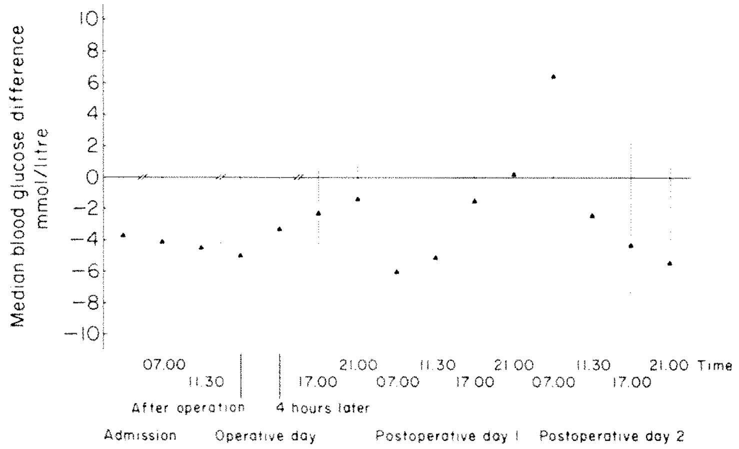

Fig. 2. The median-difference of blood glucose (GIK-conventional) with 95% confidence interval.

Statistics

Statistical analyses were performed with a combination of Mann–Whitney *U* test and Friedmann test. Comparability between groups was assessed by Mann–Whitney *U* test and Fisher's exact test. Values are given as median with the 25th and 75th quantile and ranges. A probability value of less than 0.05 was considered as significant. M-values were calculated to evaluate the efficacy of the two treatments on each patient. These were based on all blood glucose values and their flucuations on the day of operation by means of a simple formula proposed by Schlichtkrull *et al.*[11]

Results

Characteristics of the diabetic patients in the two groups are shown in Table 1. There was no difference in sex distribution, age, weight, body mass index, HbA_{1C}, daily insulin dose, fasting period or days of admission. Only two blood samples were obtained from each of two patients in the conventional group, one because local anaesthesia was chosen, the other because of a hypersensitivity reaction which required intravenous adrenaline.

The profiles of the blood glucose levels in the GIK and the conventional groups are shown in Fig. 1. The median blood glucose level differed on the day of admission ($p < 0.05$) but not at 0700 on the day of operation. The fluctuations of blood glucose differed during the infusion period on the day of operation ($p < 0.05$) and during the entire time of observation (the operative, first and second postoperative day, $p < 0.01$).

The median blood glucose differences (GIK-conventional) with 95% confidence limits are given in Fig. 2. It appears that the median blood glucose differed on the day of admission, at 1130 and 4 hours postoperatively on the day of operation, at 0700 and 1130 on the first postoperative day and at 1130 on the second postoperative day.

Forty-eight per cent of the blood glucose values in the GIK group were within the intended range of 5–10 mmol/litre as compared with only 26% in the conventional group during the observation period ($p < 0.01$). These figures were 67% and 28% respectively during the infusion period ($p < 0.0001$). In order to keep the blood glucose values within 5–10 mmol/litre supplements of subcutaneous insulin had to be given 16 times in the conventional group but only five times in the GIK group.

In the GIK group 18 blood glucose estimations from six patients were less than 5 mmol/litre (minimum 2.4 mmol/litre). In the conventional group 11 estimations of blood glucose from four patients were less than 5 mmol/litre (minimum 3.3 mmol/litre; $p < 0.25$). In the GIK group seven blood glucose estimations from six patients exceeded 15 mmol/litre compared with 30 blood glucose estimations

Table 2. The profiles of plasma 3-hydroxybutyrate (BOH), plasma lactate, plasma glycerol and plasma alanine shown as median with (25th to 75th quantile).

	BOH µmol/litre		Lactate µmol/litre		Glycerol µmol/litre		Alanine µmol/litre	
	GIK	CON	GIK	CON	GIK	CON	GIK	CON
Admission	48 (28–150)	58 (40–143)	950 (875–1250)	1050 (915–1175)	88 (63–128)	88 (44–120)	395 (370–480)	425 (325–570)
Operative day 0700	705 (340–845)	228 (103–980)	875 (725–950)	900 (800–1300)	110 (66–133)	80 (52–98)	320 (290–365)	305 (260–395)
Postoperatively	40 (14–120)	40 (20–240)	925 (750–1100)	950 (825–1060)	45 (35–85)	98 (50–100)	308 (270–340)	315 (280–345)
4 hours postoperative	175 (115–305)	135 (8–390)	875 (675–900)	750 (700–800)	88 (75–165)	65 (42–87)	265 (245–293)	240 (215–267)
1st postoperative day 0700	505 (145–700)	285 (40–1580)	825 (800–1200)	1050 (775–1150)	105 (98–157)	130 (60–160)	288 (240–405)	300 (225–360)
2nd postoperative day 0700	285 (100–400)	285 (48–580)	950 (775–1075)	950 (860–1125)	110 (100–160)	150 (67–162)	325 (280–403)	300 (235–370)

BOH, plasma 3-hydroxy-butyrate; GIK, glucose–insulin–potassium regimen; CON, conventional regimen.

Table 3. The profiles of serum human growth hormone (HGH), plasma glucagon and plasma-free insulin shown as median (with 25th to 75th quantile).

	HGH mU/litre		Glucagon pmol/litre		Free insulin mU/litre	
	GIK	CON	GIK	CON	GIK	CON
Admission	3.8	0.8	30	43	52	33
	(1.1–6.6)	(0.2–4.3)	(20–45)	(28–51)	(25–62)	(22–66)
Operative	1.1	1.1	20	40	28	21
day 0700	(0.4–2.7)	(0.6–1.1)	(15–33)	(20–64)	(15–34)	(15–27)
Postoperatively	2.0	2.0	20	28	38	31
	(1.2–8.6)	(0.6–5.5)	(20–40)	(20–38)	(27–42)	(27–47)
4 hours	5.8	3.7	28	28	34	31
postoperative	(1.4–9.5)	(1.1–6.6)	(15–40)	(20–39)	(18–34)	(15–23)
1st postoperative	1.6	2.5	30	33	26	18
day 0700	(1.2–5.0)	(1.7–3.4)	(20–33)	(12–75)	(18–34)	(15–23)
2nd postoperative	1.2	1.5	25	25	26	23
day 0700	(0.6–3.1)	(0.8–2.9)	(20–37)	(17–90)	(21–34)	(14–27)

Table 4. The profiles of haemoglobin, serum sodium and serum potassium expressed as median (with range).

	Haemoglobin mm/litre		Sodium mmol/litre		Potassium mm/litre	
	GIK	CON	GIK	CON	GIK	CON
Admission	8.9	8.1	141	140	3.8	4.2
	(7.2–10.4)	(7.5–8.8)	(133–145)	(137–145)	(3.2–4.7)	(4.0–5.1)
Operative	8.8	7.8	141	140	3.8	4.0
day 0700	(7.7–9.3)	(7.3–8.8)	(135–146)	(134–143)	(3.0–4.7)	(3.6–4.6)
Postoperatively	8.7	7.6	142	138	3.8	4.2
	(6.6–9.8)	(7.2–8.3)	(138–145)	(136–143)	(3.6–5.8)	(3.8–4.7)
1st postoperative	8.6	7.7	140	135	4.0	4.1
day 0700	(7.0–10.2)	(7.1–8.1)	(136–146)	(133–139)	(3.1–4.6)	(3.6–5.1)
2nd postoperative	8.3	7.4	140	140	4.2	4.0
day 0700	(7.1–9.6)	(7.1–8.6)	(136–145)	(135–146)	(3.1–5.1)	(4.0–5.0)

from 10 patients in the conventional group ($p < 0.00001$).

In the GIK group the median M–value was calculated to 15.8 (range 1.5–56.9). In the conventional group the median M–value was 25.9 (range 12.2–49.7). The M–values did not differ ($p < 0.17$).

The profiles of the metabolites lactate, 3-hydroxybutyrate, glycerol and alanine are shown in Table 2. They did not differ between the groups. The profiles of glucagon, insulin and growth hormone appear in Table 3. There were no differences between the groups. The values of haemoglobin, serum sodium, potassium and creatinine are shown in Table 4. Haemoglobin values were highest in the GIK group ($p < 0.05$). Serum sodium differed significantly ($p < 0.01$) at 0700 on the first day after operation; serum potassium did not differ.

The white blood cell counts were identical in the two groups pre- and postoperatively. There were no differences in the two groups for the urine concentrations of glucose, ketones and potassium. Pre-operatively two patients had positive urine cultures in the GIK group, three in the conventional group. Postoperatively the figures were two and one respectively. Chest X rays did not reveal any infective processes in the patients pre- or postoperatively.

Discussion

The peri-operative management of the metabolism in patients with insulin-dependent diabetes is difficult for many reasons. Admission to hospital is associated with an increased insulin demand. Elective surgery is preceded by a period of fasting which tends to increase lipolysis and gluconeogenesis.[12] Furthermore various anaesthetics change blood glucose levels[13] and surgical stress increases the secretion of cortisol, catecholamines, glucagon and growth hormone.[4,14,15] Improved diabetic control in patients with insulin dependent diabetes who have major surgery has been claimed to occur in response to the GIK regimen.[16–18] Little information is available however concerning metabolic and hormonal fluctuations in insulin dependent diabetic patients scheduled for minor surgery. In this study a group of such patients admitted for vitrectomy or minor hand surgery were chosen, since it provided a reproducible model of minor surgery. The anaesthetic techniques, the postoperative analgesia and the quantity and duration of the intravenous infusions were standardised as proposed by Hall.[19]

The blood glucose level differed between the two groups on the day of admission, but this might be explained by the different time the samples were taken. No difference was seen at 0700 on the day of operation nor did the concentration of HbA_{1C} differ. Therefore the two groups were considered comparable with respect to the pre-operative metabolic control.

The diabetics treated with the GIK regimen had lower blood glucose levels on the day of operation, as well as on the first and second postoperative day. Most of the blood glucose values in the GIK group were within the range 5–10 mmol/litre which is considered good metabolic control during surgery.[18] Taitleman *et al.*[17] and Bowen *et al.*[20] have reported that hypoglycaemia might be a problem when glucose–insulin infusions are used in diabetic patients during operation. This was not the case in our study. The lowest blood glucose value of 2.4 mmol/litre was measured at 0700 on the day of operation prior to the start of the GIK infusion. During the operation blood glucose increased to 3.0 mmol/litre. The M–values in the GIK group indicated that the blood glucose control was good in seven patients and poor in three patients. In the conventional group, two patients were well controlled, four were fairly well controlled, and four poorly controlled. An increment of 3-hydroxybutyrate occurred in both groups' metabolites from the day of admission to the day of operation, due to fasting.[9]

The concentration of alanine tended to decrease during the day of operation, related presumably to an increase in gluconeogenesis induced by the surgical stress response. This stress response was reflected in both groups by an increase in growth hormone concentrations of similar magnitude, although glucagon did not show any change. This indicates the minor nature of the operative procedure. The reason for the difference in the haemoglobin concentrations between the groups remains obscure. Likewise it remains uncertain why serum sodium declined in the conventional group to a minimum at the end of the infusion period. This may have been due to haemodilution because of the glucose infusion, but should have occurred in both groups. The concentration of potassium in serum and urine were considered acceptable in both groups and did not differ. Only one patient in the GIK group had a raised serum potassium (5.8 mmol/litre) postoperatively. The improved blood glucose control in the GIK group did not result in a better anti-inflammatory response to judge by the white blood cell count, urine cultures or chest X rays.

In the present study we have used one of the GIK regimens advocated by Alberti *et al.*[4] Insulin was mixed with potassium and glucose in plastic bottles without the addition of human serum albumin. One argument against mixed infusion of glucose and insulin is the absorption of insulin into the bottles and tubes. However it has been reported, that 75–90% of the added insulin is delivered if the first 50 ml are washed through the infusion system.[15,21]

In conclusion intravenous glucose–insulin–potassium infusion is a safe insulin regimen during minor surgery of insulin-dependent diabetic patients providing a better glycaemic control, peri- as well as postoperatively, than the conventional subcutaneous insulin regimen. It is simple to use and requires relatively little adjustment. Nonetheless blood glucose levels must be measured regularly. This can be done most conveniently with one of the bedside dry stix/meter methods.

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References

1. Bagdade JD, Nielson KL, Bulger RJ. Reversible abnormalities in phagocytic function in poorly controlled diabetic patients. *American Journal of the Medical Sciences* 1972; **263:** 451–6.
2. Weringer EJ, Arquilla ER. Wound healing in normal and diabetic Chinese hamsters. *Diabetologia* 1981; **21:** 394–401.
3. Galloway JA, Shuman CR. Diabetes and surgery: A study of 667 cases. *American Journal of Medicine* 1963; **34:** 177–91.
4. Alberti KGMM, Gill GV, Elliott MJ. Insulin delivery during surgery in the diabetic patient. *Diabetes Care* 1982; Suppl. 1: 65–76.
5. Christensen SE, Jørgensen OL, Møller N, Andersen KJ, Møller J, Ørskov H. A test strip method for visual and reflectometric reading of blood glucose. *Diabetic Medicine* 1985; **2:** 272–3.
6. Lloyd B, Burrin J, Smythe P, Alberti KGMM. Enzymic fluorometric continuous flow assays for blood glucose, lactate, pyruvate alanine, glycerol and 3-hydroxybutyrate. *Clinical Chemistry* 1978; **24:** 1724–9.
7. Nakagawa S, Nakayama H, Sasaki T, Yoshino K, Yu YY, Shinozaki K, Aoki S, Mashimo K. A simple method for the determination of serum free insulin levels in insulin-treated patients. *Diabetes* 1973; **22:** 590–600.
8. Schmitz O, Alberti KGMM, Ørskov H. Insulin resistance in uraemic insulin-dependent diabetics. Effect of dialysis therapy as assessed by the artificial endocrine pancreas. *Acta Endocrinologica* Copenhagen 1984; **105:** 371–8.
9. Ørskov H, Thomsen HG, Yde H. Wick chromatography for rapid and reliable immunoassay of insulin, glucagon and growth hormone. *Nature* 1968; **219:** 193–5.
10. Hayes EJ, Gleason RE, Soeldner JS, Wacks M, Blankstein L. Measurement of haemoglobin $_{A_{1c}}$ by liquid chromatography and by agar gel electrophoresis compared. *Clinical Chemistry* 1981; **27:** 476–9.
11. Schlichtkrull J, Munck O, Jerisild M. The M–value, an index of blood-sugar control in diabetics. *Acta Medica Scandinavica* 1965; **177:** 95–102.
12. Ensinck JW, Williams RH. Disorders causing hypoglycemia. In: Williams RH, ed. *Textbook of Endocrinology*. Philadelphia: WB Saunders, 1972; **5:** 543, 627–32.
13. Clarke RSJ. The hyperglycaemic response to different types of surgery and anaesthesia. *British Journal of Anaesthesia* 1970; **42:** 45–53.
14. Alberti KGMM, Thomas DJB. The management of diabetes during surgery. *British Journal of Anaesthesia* 1979; **51:** 693–710.
15. Traynor C, Hall GM. Endocrine and metabolic changes during surgery: anaesthetic complications. *British Journal of Anaesthesia* 1981; **53:** 153–60.
16. Goldberg NJ, Wingert TD, Levin SR, Wilson SE, Viljoen JF. Insulin therapy in the diabetic surgical patient: Metabolic and hormone response to low dose insulin infusion. *Diabetes Care* 1981; **4:** 279–84.
17. Taitleman U, Reece EA, Bessman AN. Insulin in the management of the diabetic surgical patient. Continuous intravenous infusion is subcutaneous administration *Journal of the American Medical Association* 1977; **14:** 658–60.
18. Thomas DJB, Platt HS, Alberti KGMM. Insulin-dependent diabetes during the peri-operative period. An assessment of continous glucose-insulin-potassium infusion, and traditional treatment. *Anaesthesia* 1984; **39:** 629–36.
19. Hall GM. Diabetes and anaesthesia—a promise unfulfilled? *Anaesthesia* 1984; **39:** 627–8.
20. Bowen DJ, Daykin AP, Nancekievill ML, Norman J. Insulin-dependent diabetic patients during surgery and labour. Use of continous intravenous insulin-glucose-potassium infusions. *Anaesthesia* 1984; **39:** 407–11.
21. Peterson L, Caldwell J, Hoffman J. Insulin adsorbance to polyvenylchloride surfaces with implications for constant-infusion therapy. *Diabetes* 1976; **25:** 72–4.

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Diabetes mellitus and anaesthesia

A survey of the peri-operative management of the patient with diabetes mellitus

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Summary

A variety of methods are currently available for the management of the diabetic patient in the peri-operative period. A questionnaire about current clinical practice was sent to all anaesthetists in the Oxford region. The majority reported that minor surgery in both insulin treated and noninsulin treated diabetic patients warranted no intervention other than avoidance of meals and medication before surgery, and that, for major surgery, a glucose–insulin–potassium infusion should be used. Fifty one out of 71 respondents in the junior staff grades preferred this latter approach for intermediate surgical procedures in insulin treated patients compared with 27 out of 69 of the consultant staff. Most anaesthetists aimed for blood glucose levels of 7–13 mmol/litre in the peri-operative period. The literature is also reviewed.

Key words

Complications; diabetes mellitus.

Diabetes mellitus is the commonest endocrine disease and affects 5–10% of the population aged 60–80 years and 1–2% of the population as a whole. These patients have an increased chance of requiring surgery and have enhanced risk of mortality associated with surgery. Wheelock and Marble[1] reported a 3.7% mortality in a series of 2780 diabetic patients and Galloway and Shuman[2] reported a 3.6% mortality with a 17.2% morbidity in a series of 667 diabetic patients. It was recognised that diabetic patients had a fatal susceptibility to infection before diabetes was treatable.[3] Poor control of diabetes results in impaired polymorphonuclear leucocyte function,[4] whereas Strom *et al.*[5] have shown that, *in vitro*, physiological levels of insulin enhance the ability of cytotoxic lymphocytes to attack target cells.

Wound healing may be impaired in diabetic surgical patients, as suggested by the work of Rosenthal *et al.*,[6] who found that the pressure required to open a sutured incision was greater in well-controlled, as opposed to poorly controlled, diabetic rats. A recent retrospective study[7] suggests, however, that if well controlled, diabetes mellitus *per se* does not increase postoperative morbidity. Two hundred and twenty-four diabetic patients, with a mean age of 68 years, who had surgery for major vascular disease, hip fracture or intra-abdominal pathology were compared to a control group matched with regard to operative procedure, sex, age, weight and treatment for cardiovascular disease. Close control of blood glucose was achieved in the diabetic group and only 9% of the diabetic patients had a pre-operative blood glucose level above 15 mmol/litre.

The accepted aims[8] of treatment of the diabetic patient during surgery are the maintenance of metabolic stability, avoidance of hypoglycaemia and prevention of gross hyperglycaemia. The methods used to achieve these goals were reviewed in 1979 by Alberti and Thomas,[8] and found to be varied, dependent both on the nature of the proposed surgery and the perceived severity of the diabetes. Diabetic patients were usually admitted pre-operatively for 'diabetic stabilisation', then given a proportion of their normal dose of insulin pre-operatively, and intravenous glucose during surgery. Postoperatively, patients were recommenced on their original therapy when normal feeding was re-established. Insulin was continued according to a 'sliding scale' regimen if this was delayed.

Some authors[9–11] recommended intravenous infusions of both glucose and insulin for intra-operative management. The use of an infusion of glucose–insulin–potassium was proposed in 1979[8] as a simple method of management for the diabetic patient during surgery and in the postoperative period. Several subsequent studies[12–15] have supported the use of this regimen, although some criticisms have been expressed.[16]

There have been several developments over the past decade which may influence the management of the diabetic patient during surgery. The routine care of the diabetic patient is aimed at the maintenance of normoglycaemia at all times in an attempt to prevent, or at least

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delay, the complications of diabetes. There is now a greater understanding of the effects of surgery on the endocrine system, and of the clinical implications of these effects. Glucose oxidase reagent strips, now used with reflectance meters, provide a reliable estimate of blood glucose within 2 minutes. This allows easy assessment during anaesthesia and so reduces the risk of undetected hypoglycaemia in an anaesthetised patient. The present study was carried out to determine which methods of diabetic management were used in current practice and what level of blood glucose was considered acceptable during and after surgery. We also wished to ascertain whether the most recently introduced method, the glucose–insulin–potassium regimen, has superseded older techniques.

Methods

The study was started in 1985 and completed during the first 3 months of 1986. All practising anaesthetists in the Oxford region were sent a questionnaire; nonresponders were sent a second questionnaire. The Oxford Area Health Authority comprises one teaching hospital and eight district general hospitals of varying sizes. Participants were asked to state their career grade and indicate which approach to the management of various groups of diabetic patients during surgery most closely fitted their normal practice. Patients were grouped according to the management of their diabetes, namely insulin treated or noninsulin treated, and to one of three grades of surgery, designated as minor, intermediate or major. Minor surgery was defined as procedures lasting up to 30 minutes which were unlikely to interfere with normal diabetic treatment e.g. cystoscopy, laparoscopy. Intermediate surgery lasted between 30 minutes and 2 hours and might interfere with normal treatment on the day of surgery, e.g. laminectomy, internal fixation of fracture; major surgery lasted more than 2 hours or was any surgery likely to interfere with normal diabetic management

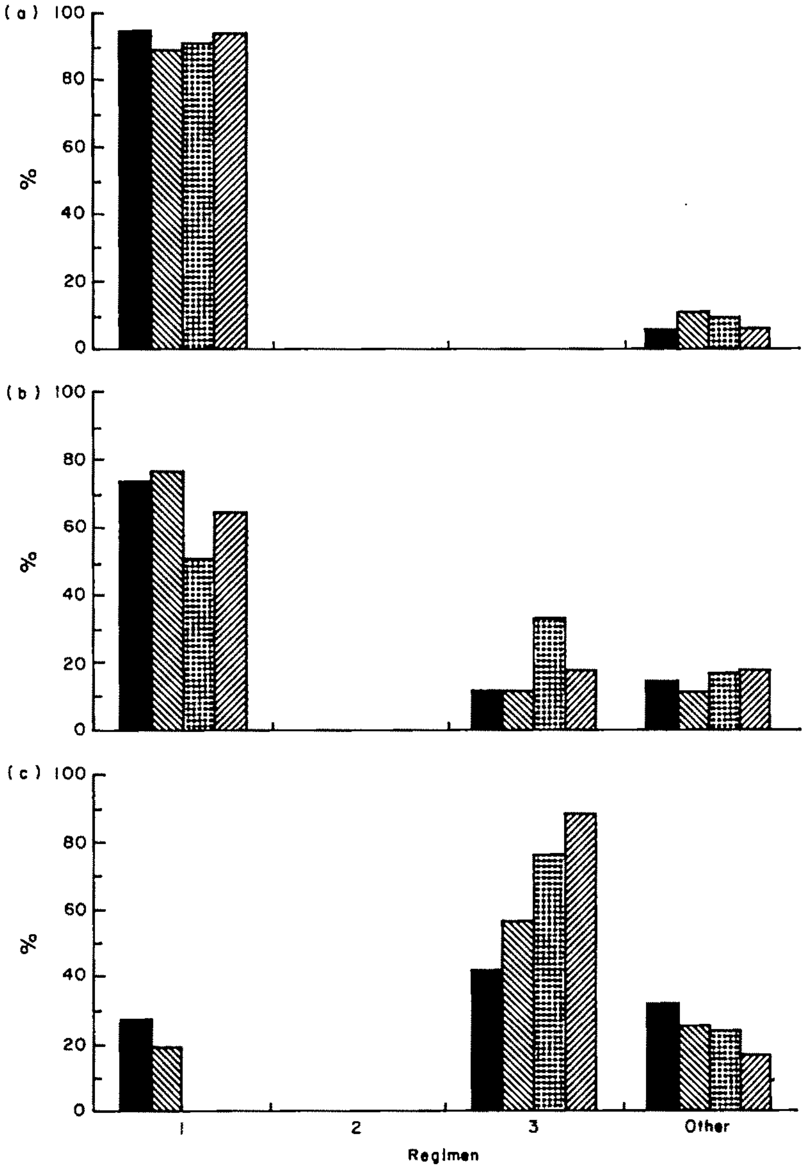

Fig. 1. Preferences expressed for the peri-operative diabetic management of noninsulin treated diabetic patients undergoing (a) minor, (b) intermediate or (c) major surgery. Regimens considered were (1) no antidiabetic therapy and no food, (2) a proportion of the patient's usual dose of insulin plus an intravenous glucose infusion, (3) a glucose–insulin–potassium intravenous infusion or (4) other methods. Responses were analysed separately according to career grade: ■, consultant; ▧, senior registrar; ⊞, registrar; ▨, senior house officer.

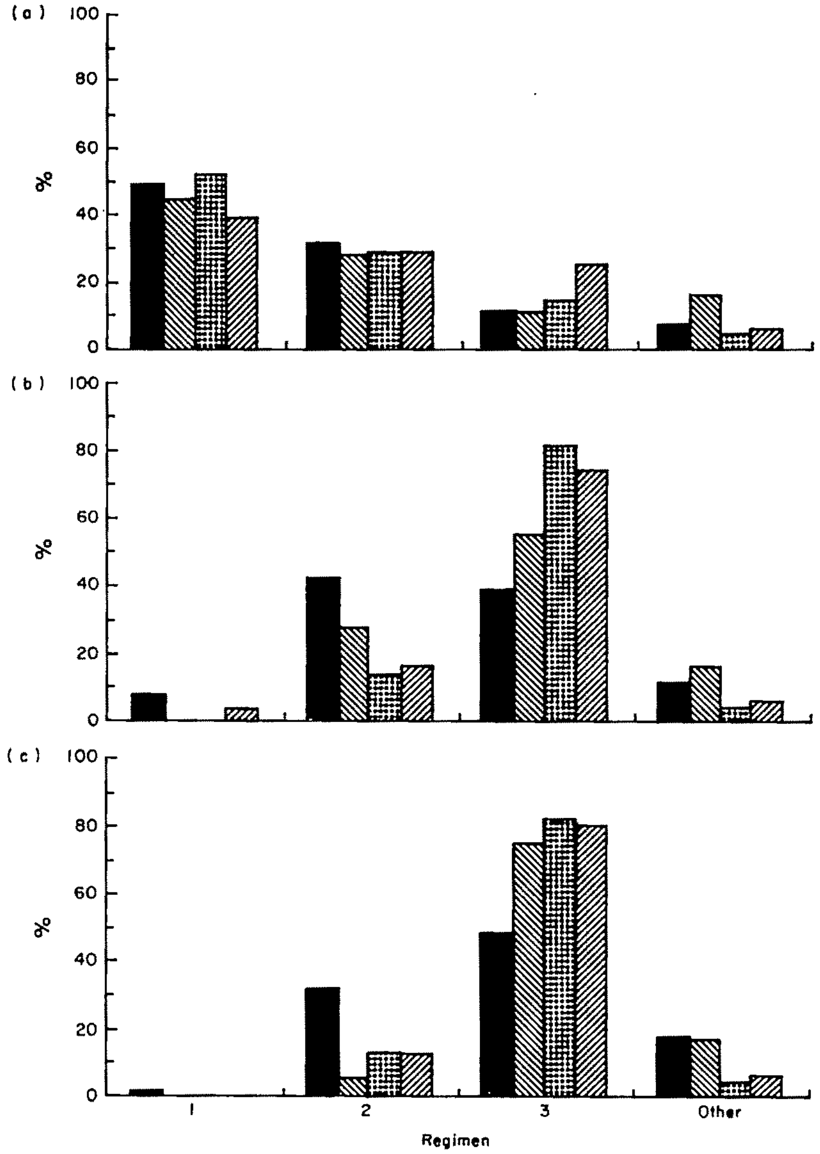

Fig. 2. Preferences expressed for the peri-operative management of insulin treated diabetic patients. Details as for Fig. 1.

and diet e.g. cholecystectomy, bowel resection, major vascular reconstruction. Examples of each of these grades and details of three common regimens for the peri-operative management of diabetes were given in a covering letter.

The options available for the day of surgery were: no antidiabetic therapy and no food; a proportion of the patient's usual insulin dose with an intravenous glucose infusion; a glucose–insulin–potassium infusion (GIK); other methods. The second and third options were regarded as 'active management'. Respondents were asked to state what proportion of the usual dose of insulin they would use and how much glucose they would give, if the second option was chosen. Finally, they were asked what level of blood glucose they aimed for, both intra-operatively and postoperatively. Six serial, mutually exclusive, ranges were given, with the values expressed both in mmol/litre and mg/decilitre, and respondents were asked to choose one or more of these ranges.

Results

Of the 222 questionnaires distributed, 130 replies were received after the first mailing, a further 26 followed a second mailing. One hundred and fifty-three valid returns were received from 69 consultants, 18 senior registrars, 23 registrars, 32 senior house officers and 11 other grades, either associate specialist or clinical assistant. Three returns were spoilt and not included in the analysis. The response rates were similar in all grades.

The unequivocal choice of diabetic management, analysed according to pre-existing diabetic treatment, category of surgery, and career grade of the respondent, is shown for the noninsulin treated and insulin treated groups of diabetic patients in Figs 1 and 2 respectively. Those respondents who opted for more than one choice or were unable to choose a particular method, were excluded as undecided. The options chosen by the associate specialist grade closely match those of the consultant grade and for the purposes of analysis they have been counted as one group.

Noninsulin treated diabetic patients (Fig. 1)

A large measure of agreement between grades of anaesthetists was obtained for the noninsulin treated diabetic undergoing minor surgery, where the simplest option was chosen by approximately 90% of all respondents. Inter-

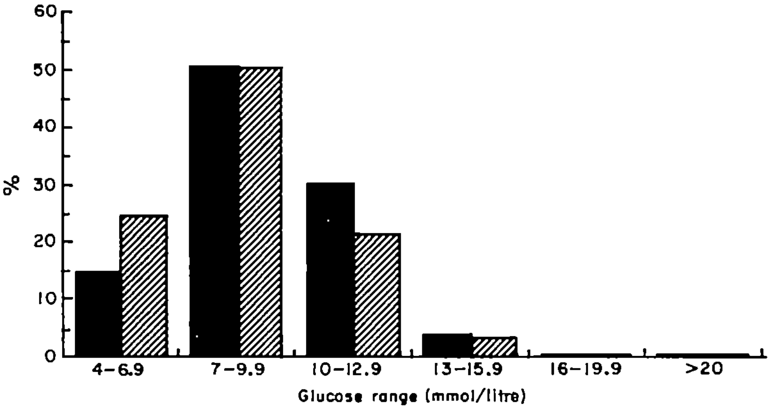

Fig. 3. Glucose values preferred by anaesthetists for diabetic patients during the intra-operative (■) and postoperative (■) periods.

mediate surgery in this group was also treated passively by the majority of all grades except registrars, six out of 18 of whom chose GIK infusion. Major surgery was managed more actively with descending seniority, 17 out of 63 of consultant respondents favoured passive management, and of the remainder, 26 used a GIK infusion. The senior house officer (SHO) group all chose active management and 25 out of 30 used a GIK infusion.

Insulin treated diabetic patients (Fig. 2)

In the insulin treated group undergoing minor surgery, consultant, senior registrar and registrar grades were equally divided between active and passive management. However, 19 out of 31 of the SHO grade respondents favoured active management. Intermediate and major surgery in this group was managed actively by all grades with training grades preferring a GIK infusion. Only the consultant grade did not show a clear preference for GIK infusion for major surgery. Other options chosen ranged between glucose infusions with no other treatment, the use of intravenous glucose, and insulin delivered by syringe pump or intermittent bolus injection. This last method was particularly favoured for the management of either type of diabetic during major surgery. The use of a 'sliding scale' for insulin dosage was also mentioned by several respondents. Peri-operative management was decided in two centres in conjunction with the local diabetic physician. Most respondents (81%) aimed for blood glucose levels between 7 and 12.9 mmol/litre (126–233 mg/dlitre) intra-operatively, whilst the lower range of 4–6.9 mmol/litre was accepted by more respondents postoperatively (Fig. 3).

Discussion

The response rate to the questionnaire of 69% compares favourably with the 61% achieved in a recent study of pre-operative assessment.[17] The results confirm that there is a wide variation in the peri-operative management of the diabetic patient and suggests that no one method is ideal. The choice of regimen was found to be dependent on several variables, notably the pre-existing management of the patient, the expected interference with normal management because of the proposed surgery, and the personal preference of the anaesthetist involved. This preference was influenced by local factors such as the availability of particular equipment, and the expertise of other staff involved in the care of the patient, but the seniority of the anaesthetist appears to be a major factor. Senior grades manage the diabetic patient less aggressively in the minor and intermediate surgery groups, and are less likely to use a GIK regimen than their junior colleagues for major surgery. This may reflect satisfaction with the older methods of management in use or, perhaps, unfamiliarity with the Alberti regimen. However, the training grades favour the use of a GIK infusion for all diabetic patients except those noninsulin treated patients who have minor surgery. It would appear that the more junior the anaesthetist the more likely he or she is to use an infusion technique.

The intention to avoid hypoglycaemia during anaesthesia was reflected in the majority of respondents who aimed for blood glucose levels between 7 and 12.9 mmol/litre (126–233 mg/dlitre) intra-operatively. Attempts to avoid the hazards of unrecognised hypoglycaemia during anaesthesia presumably explain the infusion of 5% dextrose without insulin to patients who have intermediate or minor surgery. However, Fletcher and colleagues,[18] have shown that blood glucose values are usually stable during such surgery if neither insulin nor glucose is given. The need for routine glucose infusions which, in some cases, will require the additional use of insulin is, therefore, uncertain.

In conclusion, the GIK infusion regimen, although favoured by the training grades, has failed to achieve universal acceptance. It is not clear whether this is because it may not give uniformly good control of blood glucose or because of satisfaction with alternative methods. However, in the future anaesthetists may aim, as do diabetic physicians, for near normoglycaemia rather than for 'safe' short-term hyperglycaemia in the peri-operative period, and each proposed regimen must be assessed on its ability to achieve this, as safely and as simply as possible.

References

1. Wheelock FC, Marble A. Surgery and diabetes. In: Marble A, White P, Bradley RF, Krall LP, eds. *Joslin's diabetes mellitus.* Philadelphia: Lea and Febiger, 1971: 559.
2. Galloway JA, Shuman CR. Diabetes and surgery. A study of 667 cases. *American Journal of Medicine* 1963; **34:** 177–91.
3. Treves F. *System of surgery.* London 1896; **1:** 268.
4. Bagdade JD, Neilson KL, Bulger RJ. Reversible abnor-

malities in phagocytic function in poorly controlled diabetic patients. *American Journal of the Medical Sciences* 1972; **263:** 451–6.

5. Strom TB, Bear RA, Carpenter CB. Insulin-induced augmentation of lymphocyte-mediated cytotoxicity. *Science* 1975; **187:** 1206–8.
6. Rosenthal S, Lerner B, DiBiase F, Enquist IF. Relation of strength to composition in diabetic wounds. *Surgery Gynecology and Obstetrics* 1962; **115:** 437–42.
7. Hjortrup A, Sorenson C, Dyremose E, Hjortso N-C, Kehlet H. Influence of diabetes mellitus on operative risk. *British Journal of Surgery* 1985; **72:** 783–5.
8. Alberti KGMM, Thomas DJB. The management of diabetes during surgery. *British Journal of Anaesthesia* 1979; **51:** 693–710.
9. Taitelman U, Reece EA, Bessman AN. Insulin in the management of the diabetic surgical patient. Continuous intravenous infusion vs subcutaneous administration. *Journal of the American Medical Association* 1977; **237:** 658–60.
10. Beaser SB. Surgical management. In: Ellenberg M, Rifkin H, eds. *Diabetes mellitus: theory and practice.* New York: McGraw Hill, 1970; 746.
11. Oakley WG, Pyke DA, Taylor KW. *Diabetes and its management.* Oxford: Blackwell, 1978; 131.
12. Bowen DJ, Nancekievill ML, Proctor EA, Norman J. Perioperative management of insulin-dependent diabetic patients. Use of continuous intravenous infusion of insulin–glucose–potassium solution. *Anaesthesia* 1982; **37:** 852–5.
13. Bowen DJ, Daykin AP, Nancekievill ML, Norman J. Insulin-dependent diabetic patients during surgery and labour. Use of continuous infusion insulin–glucose–potassium infusions. *Anaesthesia* 1984; **39:** 407–11.
14. Thomas DJB, Platt MS, Alberti KGMM. Insulin-dependent diabetes during the peri-operative period. An assessment of continuous glucose–insulin–potassium infusion, and traditional treatment. *Anaesthesia* 1984; **39:** 629–37.
15. Husband DJ, Thai AC, Alberti KGMM. Management of diabetes during surgery with glucose–insulin–potassium infusion. *Diabetic Medicine* 1986; **3:** 69–74.
16. Hall GM. Diabetes and anaesthesia—a promise unfulfilled? *Anaesthesia* 1984; **39:** 627–8.
17. Curran J, Chmielewski AT, White JB, Jennings AM. Practice of preoperative assessment by anaesthetists. *British Medical Journal* 1985; **291:** 391–3.
18. Fletcher J, Langman MJS, Kellock TD. Effect of surgery on blood-sugar levels in diabetes mellitus. *Lancet* 1965; **2:** 52–4.

P, 24,524.

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Respiratory criteria of fitness for surgery and anaesthesia

J. F. NUNN, J. S. MILLEDGE, D. CHEN AND C. DORE

Summary

A retrospective analysis has been undertaken of 53 operations in 42 patients with severe chronic obstructive airway disease. All patients had a forced expiratory volume in 1 second between 0.3 and 1 litre, but the outcome of surgery was successful after their first operations, all of which were elective; 38 of the 42 had uneventful anaesthesia and surgery together with a normal postoperative period, while four had artificial ventilation of the lungs. The best predictors of the use of postoperative ventilation were the arterial $P\mathrm{O}_2$ *and whether the patient was dyspnoeic at rest.*

Key words

Anaesthesia; general, regional.
Lung; obstructive lung disease.

Much has been written about pre-operative pulmonary function testing, although there is a dearth of outcome studies on which to provide a basis for interpretation of results, particularly in respect of surgery which does not involve the lungs. Nevertheless, batteries of pulmonary function tests continue to be recommended widely. The forced expiratory volume in one second (FEV$_1$) is the most commonly performed of these, but there is no agreement on what value predicts an unfavourable outcome. Schwaber[1] has recommended that 'all but emergency life-saving surgery should be avoided or delayed' if FEV$_1$ is below 0.5 litre, while Benumof and Alfery[2] regard a value of less than 2 litres as presenting 'excessive risk'. These figures do not appear to have been based on any hard data of outcome. Almost no attention has been given to the significance of pre-operative arterial blood gas tensions.

Twelve years ago, we reported a small series of patients who withstood surgery successfully in spite of having FEV$_1$ values within the range 0.45–1.00 litre,[3] the lowest which had then been reported in relation to pre-operative assessment. We also stressed the value of blood gases to predict the requirement for postoperative ventilation. These observations were often cited but never challenged or confirmed. We have therefore extended the series to 42 patients who underwent nonpulmonary surgery with FEV$_1$ of 1 litre or less, and also extended our consideration of risk factors.

Methods

Patients

Clinical data of 53 operations undergone by 42 patients (Table 1) with chronic obstructive airway disease have been analysed retrospectively. Ten of these patients, who had 12 operations under general anaesthesia, were included in the survey of Milledge and Nunn in 1975.[3] Any patient who presented for surgery with FEV$_1$ of 1 litre or less, and for whom pre-operative blood gas data and peak flow were available, was included in the study. All of the first operations were elective and included no cardiac or pulmonary surgery.

Pre-operative assessment. We graded dyspnoea from the record of the pre-operative visit, according to the classification of Roizen[4] which is outlined in Table 2. Routine spirometry was undertaken by the Pulmonary Function Testing Service of Northwick Park Hospital. FEV$_1$ and forced vital capacity were measured, as the best of three attempts, with a Vitalograph, and peak flow with a Wright peak flow meter. FEV$_1$ is reported both as the measured value and as a percentage of the predicted value for age and height.[5] Arterial samples were withdrawn from the radial artery while the patient was supine and breathing air. $P\mathrm{CO}_2$ and $P\mathrm{O}_2$ were measured with an Instrumentation Laboratory automated analyser. Arterial $P\mathrm{O}_2$ is reported

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Table 1. Data of patients at time of first operation.

Patient number	Age (years)	Dyspnoea grade	FEV_1 (litres)	FEV_1 (% of predicted)	FEV_1/VC (%)	Peak flow rate (PFR) (litres/minute)	Pa_{CO_2} (kPa)	Pa_{O_2} (kPa)	Pa_{O_2} (% of predicted)	IPPV during operation	Upper abdominal surgery	Regional anaesthesia	IPPV after operation (hours)
1	79	4	0.40	17	40	50	5.9	6.5*	64.4	Yes	Yes	No	24
2	78	4	0.70	23	58	160	7.6*	5.9*	57.8	No	No	Yes	0
3	73	4	0.60	23	26	85	5.3	7.1*	68.3	Yes	Yes	No	0
4	74	3	0.65	23	65	135	5.2	8.7*	84.5	Yes	Yes	No	0
5	76	4	0.30	11	33	60	4.9	7.1*	68.9	Yes	No	No	2
6	76	3	0.50	21	33	130	5.7	10.3	100	No	No	Yes	0
7	59	2	0.80	25	36	160	4.5	10.7	97.2	No	No	Yes	0
8	61	1	0.50	25	33	160	4.5	10.8	99.0	Yes	No	No	0
9	70	2	0.70	25	33	280	5.1	9.2	87.6	Yes	Yes	No	0
10	64	3	1.00	36	45	160	5.7	10.3	95.4	Yes	Yes	No	0
11	62	2	0.70	25	36	100	7.6*	7.1*	65.1	No	No	Yes	0
12	60	4	0.30	16	37	70	5.4	6.5*	59.1	Yes	No	No	0
13	60	2	0.40	13	23	105	5.3	11.5	104.5	No	No	Yes	0
14	87	4	0.40	19	40	90	5.2	11.6	118.4	No	No	Yes	0
15	76	3	0.40	17	40	95	5.6	8.4*	81.6	No	No	No	0
16	73	2	1.00	38	45	170	4.7	11.4	109.6	Yes	Yes	No	0
17	76	4	0.90	38	51	190	6.2*	7.5*	72.8	No	No	No	0
18	62	3	0.60	32	66	50	4.2	8.8*	80.7	Yes	No	No	0
19	79	4	0.64	45	33	195	5.1	9.2	91.1	No	No	Yes	0
20	70	0	0.65	25	37	155	7.0*	7.9*	75.2	Yes	No	No	0
21	86	1	0.90	41	50	130	5.9	8.9	90.8	No	No	Yes	0
22	62	3	0.50	15	47	120	4.3	7.5*	68.8	Yes	Yes	No	0
23	80	3	0.50	33	50	70	4.5	11.6	114.9	Yes	No	No	0
24	77	1	0.95	59	68	235	5.8	7.1*	69.6	Yes	Yes	No	0
25	77	3	0.50	34	56	90	6.7*	7.6*	74.5	No	No	Yes (+ GA)	0
26	68	1	0.75	37	46	130	4.4	11.2	105.7	No	No	No	0
27	85	1	0.60	27	35	100	4.9	6.7*	67.7	Yes	No	No	0
28	76	3	0.30	16	50	60	5.1	6.9*	67.0	Yes	No	No	0
29	72	1	0.45	24	60	85	4.8	6.1*	58.7	Yes	No	No	0
30	72	2	0.60	35	75	120	5.2	9.9	95.2	Yes	Yes	No	0
31	67	3	0.40	19	44	90	6.5*	9.1*	85.0	No	No	Yes	0
32	74	3	0.60	21	19	100	4.7	10.4	101.0	No	No	Yes	0
33	56	4	0.88	37	28	155	5.6	10.7	96.4	No	No	No	0
34	57	2	0.82	30	47	135	5.1	10.6	95.5	Yes	Yes	No	0
35	77	4	0.86	41	37	138	5.6	10.5	103.0	Yes	No	No	0
36	70	4	1.00	34	48	180	6.8*	6.4*	61.0	Yes	No	No	24
37	69	3	0.88	34	48	175	6.0	8.8*	83.0	Yes	No	No	0
38	73	2	0.77	49	64	110	4.4	7.8*	75.0	Yes	No	No	0
39	69	2	0.80	27	38	157	5.0	7.2*	67.9	Yes	Yes	No	0
40	64	2	0.54	48	31	110	6.6*	8.5*	78.7	Yes	No	No	0
41	65	3	0.45	24	34	90	5.8	7.6*	71.0	No	No	No	0
42	70	3	0.50	35	35	130	7.6*	5.9*	56.2	Yes	Yes	No	120

* Values outside the 95% reference ranges.

Table 2. Roizen's classification of dyspnoea.[4]

Grade O	No dyspnoea while walking on the level at a normal pace
Grade I	'I am able to walk as far as I like provided I take my time'.
Grade II	Specific street block limitation—'I have to stop for a while after one or two blocks'.
Grade III	Dyspnoea on mild exertion— 'I have to stop and rest while going from the kitchen to the bathroom'.
Grade IV	Dyspnoea at rest

as the measured value and as a percentage of the normal for the patient's age. Normal arterial $P\mathrm{CO}_2$ does not change significantly with age. Normal values and reference ranges for arterial $P\mathrm{CO}_2$ and $P\mathrm{O}_2$ (as a function of age) were taken from Nunn.[6]

Pre-operative management. Chest physiotherapy was started some days before surgery in almost every patient in this series, and continued into the postoperative period. Existing drug therapy was continued and prophylactic antibiotics were given as necessary. Eighteen patients received opiates as premedication, and almost all were given atropine.

Anaesthetic management. General anaesthesia was used without any regional block for 38 operations (Table 3). Seven of these were managed without tracheal intubation and with spontaneous breathing, using a simple non-rebreathing system, facemask and pharyngeal airway; the others were paralysed and their lungs ventilated artificially. Induction was with thiopentone 2–4 mg/kg, diazepam, or methohexitone 1.5 mg/kg. Spinal or epidural analgesia was used for 15 operations. Two of these patients also received general anaesthesia; one breathed spontaneously, the other was paralysed and mechanical ventilation employed. The choice of anaesthetic technique was entirely that of the 22 anaesthetists concerned; they were aware of the pre-operative assessment of respiratory function but unaware that their records would be analysed.

Statistical analysis

A stepwise discriminant analysis was performed between patients who did and those who did not receive postoperative ventilation after their first operation. The best single discriminatory variable was selected; then the best pair of variables (including the first) was determined, and so on until the addition of a further variable was not significant

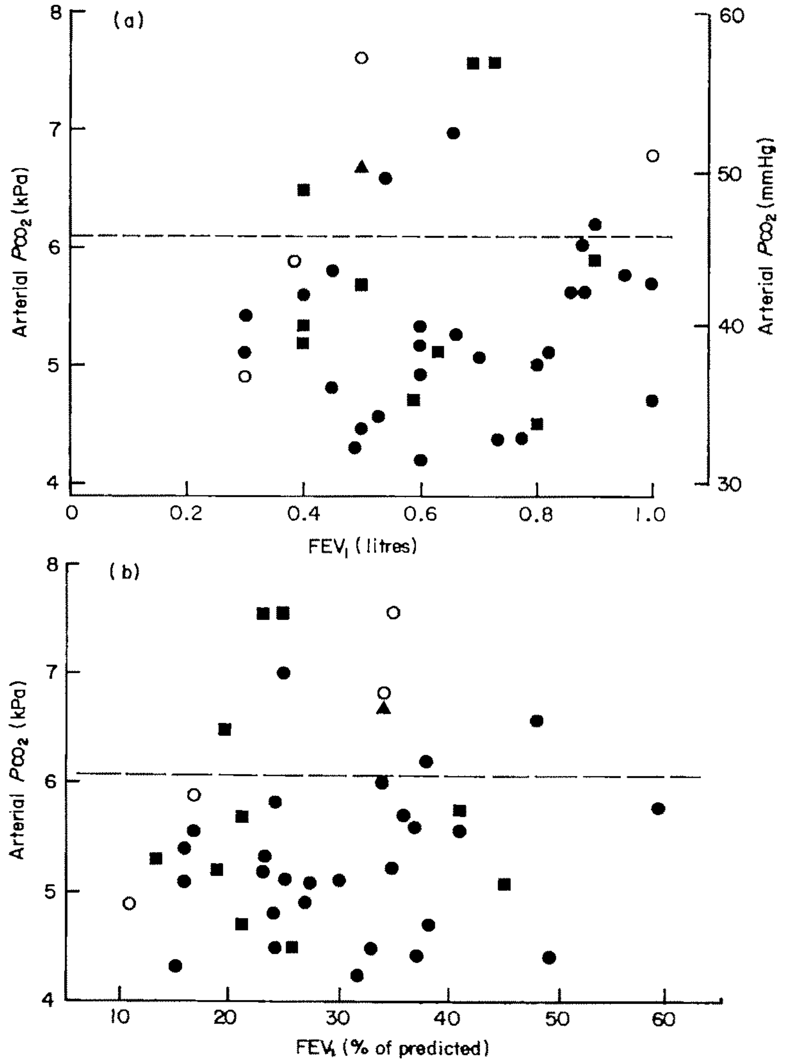

Fig. 1. Pre-operative values for FEV$_1$ (a, measured values; b, as percentage of predicted) and arterial $P\mathrm{CO}_2$. ●, general anaesthesia; ■, regional anaesthesia; ▲, combined regional and general anaesthesia; ○, artificial ventilation after the first operation (general anaesthesia); ----, the upper limit of the normal reference range for $P\mathrm{CO}_2$.

Table 3. Anaesthetic management.

	First operation		Subsequent operations		
				Postoperative ventilation	
	Uneventful recovery	Postoperative ventilation	Uneventful recovery	Recovered	Died
General anaesthesia only	27	4	5	1	1
General and regional anaesthesia	1	0	1	0	0
Regional only	10	0	3	0	0
Total	38	4	9	1	1

No mortality after first operations.

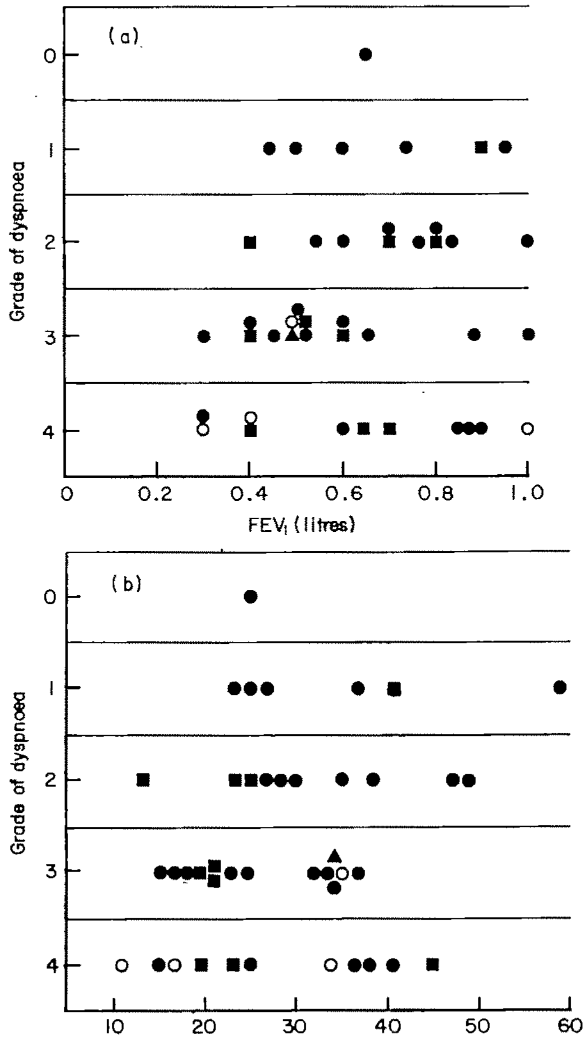

Fig. 2. Pre-operative values for FEV$_1$ (a, measured values; b, as percentage of predicted) and the grade of dyspnoea. Symbols as for Fig. 1.

at the 5% level. Correlation coefficients were calculated to relate pre-operative factors other than dyspnoea grade, for which Spearman's rank correlation coefficients were used.

Results

Pre-operative factors

The mean age of the patients was 71.0 (SD 7.9) years. FEV$_1$ ranged from 0.3 to 1.0 litre or 11 to 59% of predicted (Table 1); neither the actual FEV$_1$ nor the percentage of predicted value correlated significantly with arterial $P\text{CO}_2$ (Fig. 1) or the grade of dyspnoea (Fig. 2). FEV$_1$ did, however, correlate with peak flow ($r = 0.684$; $p < 0.001$, Fig. 3). Arterial $P\text{CO}_2$ was above the 95% reference range in nine patients, the highest values being 7.6 kPa (57 mmHg) in three patients (Figs 1 and 4). Arterial $P\text{O}_2$ was below the 95% reference range (corrected for age) in 25 patients in all of whom $P\text{O}_2$ was less than 86% of the normal for age. ($P\text{CO}_2$ and $P\text{O}_2$ values outside the 95% reference ranges are indicated with an asterisk in Table 1.) The lowest values were 5.9 kPa (44 mmHg), or 56–58% of predicted, in two patients (Fig. 4). There was a significant negative correlation between $P\text{CO}_2$ and $P\text{O}_2$ ($r = -0.442$, $p = 0.003$) and between $P\text{CO}_2$ and percentage of predicted $P\text{O}_2$ ($r = -0.436$, $p = 0.003$). Eleven patients were dyspnoeic at rest (Grade 4).

Outcome after first operation

There was an uneventful postoperative course after 27 of the 31 operations under general anaesthesia and in all of the 11 patients who received spinal or epidural analagesia, one of whom also received general anaesthesia (Tables 1 and 3). All of the seven patients who were allowed to breathe spontaneously during general anaesthesia had an uneventful postoperative course but all the operations were minor. All 38 patients spent the usual time in the recovery room and returned to the ward in the normal course of events. Ventilation was not continued after the end of the operation in any of these patients. There was no postoperative exacerbation of the respiratory disease and discharge from hospital was governed by their surgical rather than medical condition.

Four patients (numbers 1, 5, 36 and 42) received postoperative ventilation in the Intensive Care Unit (ICU) for periods that ranged from 2 to 120 hours (Table 1). Their operations are indicated by open symbols in Figs 1–5. We cannot say with certainty that these patients *required* postoperative ventilation, but the anaesthetist in charge considered that such treatment was the wisest course of action. This contrasts with the other 38 patients for whom we can say categorically that postoperative ventilation was not necessary. Surgery could not be considered contraindicated for any patient in the series. The aims of surgery were successfully achieved in all cases with or without postoperative ventilation. There was no mortality within several weeks of the first operation.

Outcome after subsequent operations

Nine patients had a total of 11 subsequent operations (Table 4). Patient 1 had two operations six months apart,

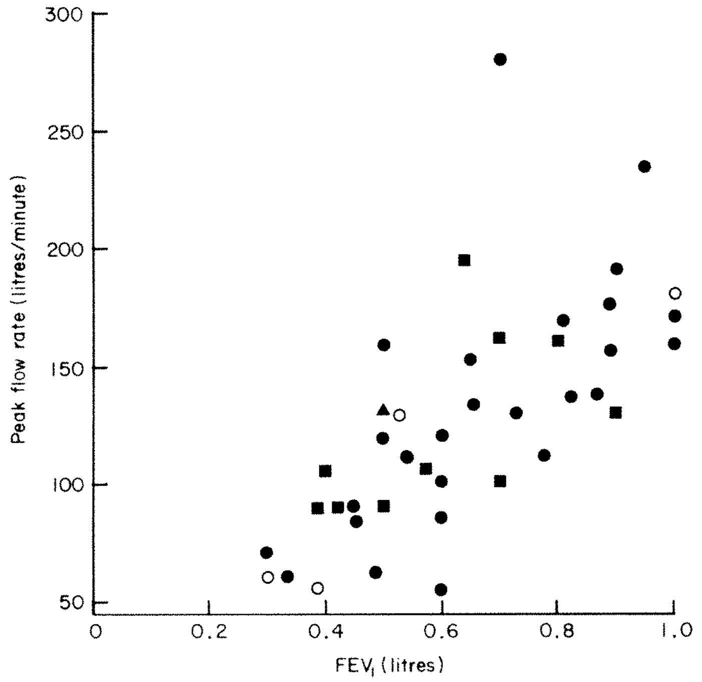

Fig. 3. Pre-operative values for FEV$_1$ and peak flow rate. Symbols as for Fig. 1. ($r = 0.684$, $p < 0.001$).

the first with general anaesthesia, the second with spinal. He received mechanical ventilation for 24 hours after the first procedure. He was monitored after the second in ICU but artificial ventilation was not used. Patient 4 had uneventful recoveries after two general and one spinal anaesthetic. Patient 26 had an uneventful recovery after both a general anaesthetic and also a combined general and epidural anaesthetic.

Patients 20 and 22 required emergency laparotomies for bleeding from stress ulceration. Both were ventilated after their last operations and patient 20 died 19 days after his third operation. However, their condition after emergency laparotomy was determined primarily by the surgical condition, and respiratory factors were not the main consideration. The remaining four patients had a repeat of their first anaesthetic and had uneventful recovery on both occasions.

Analysis of risk factors

This analysis was confined to the outcome after first operations. Analysis of pre-operative risk factors showed that prediction of those patients who would be ventilated in the postoperative period was best by arterial Po_2 either as

Table 4. Patients who underwent more than one operation.

Patient number	Operation	Interval from previous operation	Anaesthetic	Postoperative ventilation, days
1	Partial gastrectomy	—	general*	1
	Hernia and prostate	28 weeks	spinal	0
4	Cholecystectomy	—	general*	0
	Plate fractured femur	4 years	spinal	0
	Excision of mass from abdominal wall	6 months	general*	0
20	Knee replacement	—	general*	0
	Laparotomy (emergency)	17 days	general*	0
	Laparotomy (emergency)	5 days	general*	19 (died)
22	Cholecystectomy	—	general*	0
	Laparotomy	32 days	general*	0.5
26	Sigmoidoscopy	—	general	0
	Colectomy	2 weeks	epidural and general*	0
29	Compound fracture of tibia	—	general*	0
	Closed reduction and nail	6 weeks	general	0
32	Sigmoidoscopy	—	spinal	0
	TUR prostate	18 months	spinal	0
34	Sigmoid colectomy	—	general*	0
	Closure colostomy	3 weeks	general*	0
41	Pacemaker removed	—	general	0
	Pacemaker inserted	6 months	general	0

* These patients were paralysed and their lungs ventilated artificially during operation.

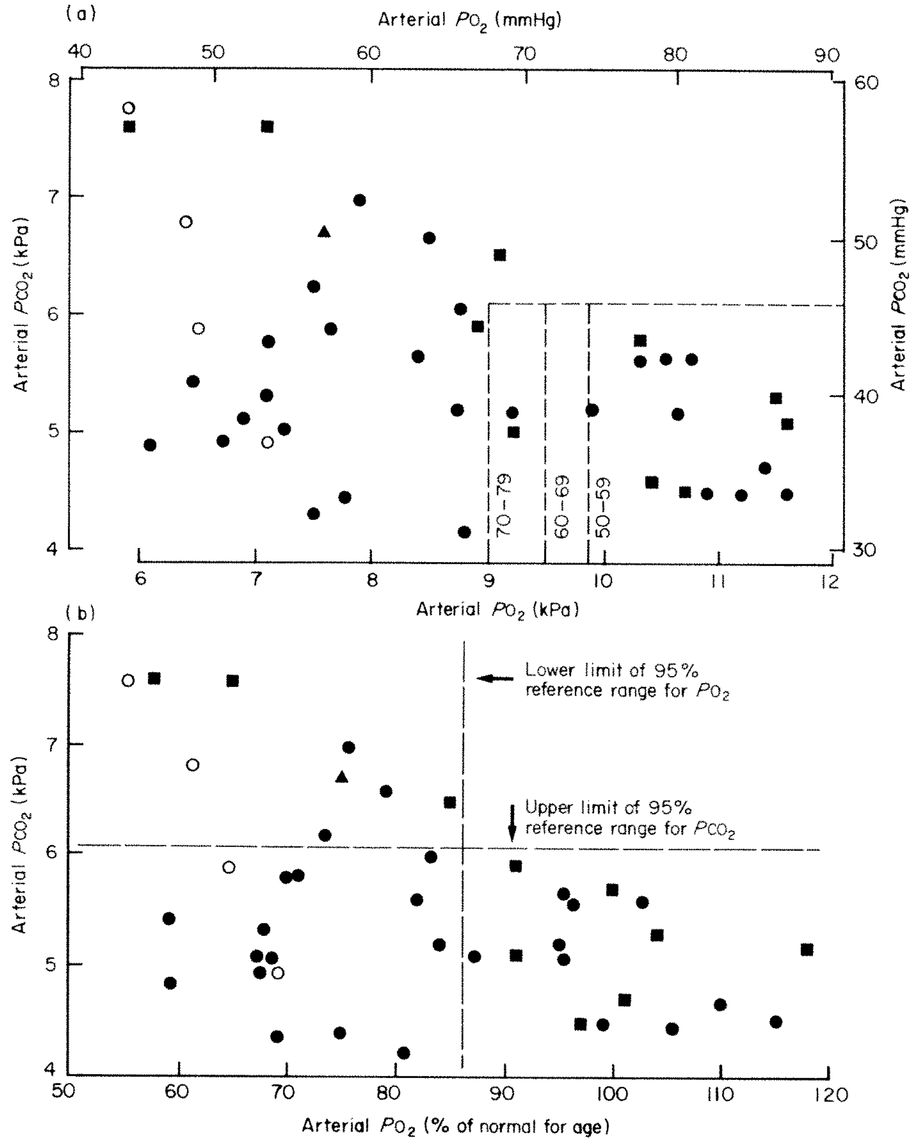

Fig. 4. Pre-operative values for arterial P_{O_2} (a, measured values; b, as percentage of predicted) and P_{CO_2}. Symbols as for Fig. 1. The horizontal broken line in (a) indicates the upper limit of the normal reference range for P_{CO_2}; the vertical broken lines in (a) indicate the lower limits of the normal reference ranges for P_{O_2} for different ages. (For measured values of arterial P_{O_2}, $r = -0.422$, $p = 0.003$; for percentage of normal for age, $r = -0.436$, $p = 0.003$).

measured value or as percentage of normal for age (Table 5), and secondly by the presence or absence of dyspnoea at rest (grade 4) (Fig. 5). Taking these two factors into account, age, upper abdominal surgery, the use of regional analgesia, FEV_1 (measured and percentage of predicted), peak flow, FEV_1/vital capacity ratio and P_{CO_2} had no further significant predictive value.

Discussion

The major finding of this study is that a high proportion of patients with FEV_1 in the range 0.3 to 1 litre can undergo anaesthesia and general surgery successfully without special postoperative care. In the remainder, outcome was successful after periods of postoperative ventilation in ICU. There would seem to be no basis for withholding surgical intervention in patients purely on the basis of a reduced ventilatory capacity.

There are relatively few studies of outcome after surgery in patients with major respiratory disability and almost none in which it is possible to relate outcome to indices of pre-operative pulmonary function. In 1961, Scott[7] reported results of major surgery in a series of 1300 elderly patients of comparable age to those in our own study. He found mortality in patients with 'emphysema' was 16.8%, and with 'bronchitis' 20%, compared with an overall mortality of 13.9%. There were no deaths in 16 patients classified as 'chronic bronchitis + emphysema', but there was no indication of severity of the condition. A more recent study of 108 878 anaesthetics[8] found a per- and postoperative mortality rate of 5.1% in patients classified according to pre-operative condition as 'chronic lower respiratory tract infection' (the only classification that related to the respiratory system). This compared with an overall mortality of 5.9% in patients in the same series over the age of 64 (74% of the patients in our own study were over 64).

In one of the very few studies to relate pulmonary function tests to outcome, Stein *et al.*[9] reported six patients with values of FEV_1 in the range 0.59–0.95 litre in a series of 30 surgical patients with one or more abnormal pulmonary

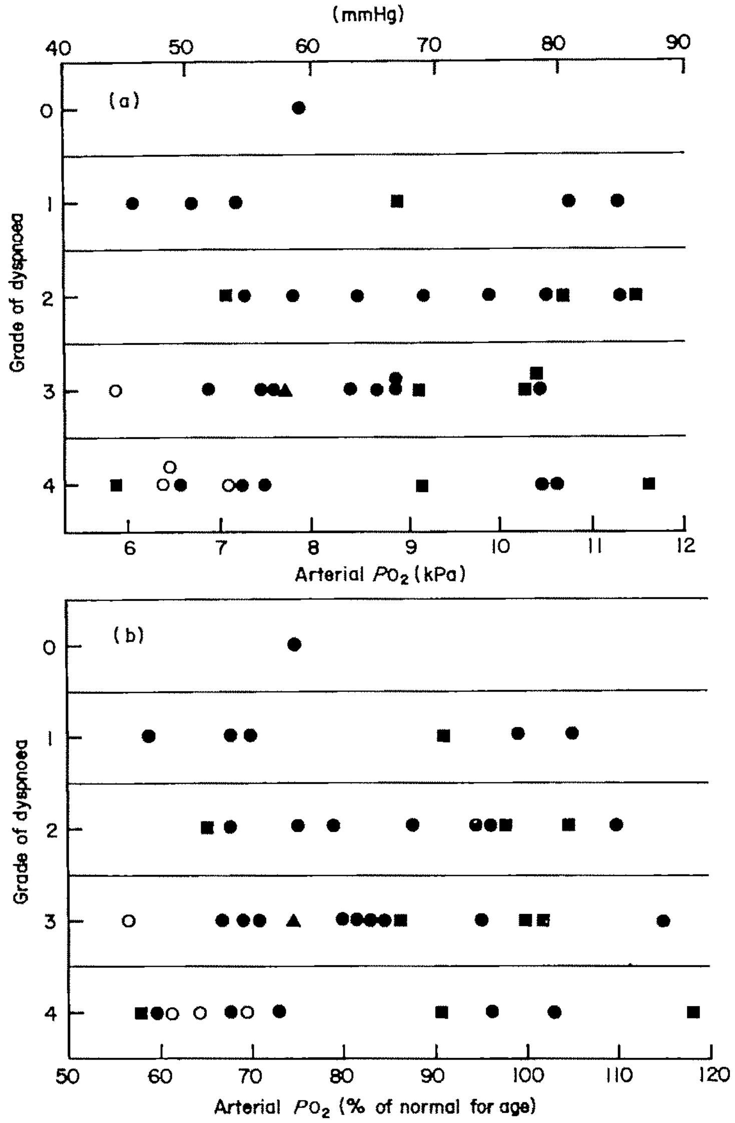

Fig. 5. Pre-operative values for arterial Po_2 (a, measured values; b, as percentage of predicted) and grades of dyspnoea. Symbols as for Fig. 1. Note that all the patients whose lungs were ventilated postoperatively are clustered in the lower left hand corner.

Table 5. Stepwise discriminant analysis to distinguish between those patients who did/did not receive postoperative ventilation.

	Step		
	0	1	2
Variable	$F_{1,40}$	$F_{1,39}$	$F_{1,38}$
Age	0.5	0.7	0.2
FEV_1 (measured)	0.8	0.2	0.3
(% of predicted)	0.9	0.5	0.3
FEV_1/VC %	0.5	1.5	0.6
Peak flow	0.8	0.4	0.5
Pco_2	3.4	0.7	0.4
Po_2 (measured)	7.6 (p = 0.009)		
(% of normal for age)	7.0 (p = 0.01)		
IPPV during operation	2.8	1.2	2.2 (p = 0.15)
Upper abdominal surgery	1.0	0.7	1.5
Regional anaesthesia	1.6	0.5	0.7
Dyspnoea grade ≥ 4	6.0	4.8 (p = 0.03)	
" ≥ 3	3.1	2.5	0.4
" ≥ 2	0.9	1.2	0.3
" ≥ 1	0.1	0.3	0.1

F-Ratios test whether the entry of each variable would significantly improve discrimination at each step in the analysis; the best additional variable at each step is underlined. The last seven variables were coded 1 for true, 0 for false.

Column 1 includes values for FEV_1 and Po_2 considered both as measured and as % of predicted. In columns 2 and 3, values relate only to Po_2 as % of predicted.

Table 6. Five patients with the worst discriminant function who did not require postoperative ventilation.

Age	Dyspnoea grade	FEV_1 (litres)	% of predicted FEV_1	$Pa\mathrm{CO}_2$ (kPa)	$Pa\mathrm{O}_2$ (kPa)	% of normal $Pa\mathrm{O}_2$ for age	Operation	Anaesthesia
78	4	0.7	23	7.6*	5.9*	57.8	TUR prostate	Regional
73	4	0.6	23	5.3	7.1*	68.3	Laparotomy	General
60	4	0.3	16	5.4	6.5*	59.1	Gordon screws	General
76	4	0.9	38	6.2*	7.5*	72.8	Cystoscopy	General
79	4	0.6	45	5.1	9.2	91.1	Cystodiathermy	Regional

* indicates values outside reference range.

function test. They did not report any mortality or the use of postoperative ventilation. The patient with the lowest FEV_1 had severe dyspnoea and carbon dioxide retention after an emergency laparotomy. Pre-operative alveolar $P\mathrm{CO}_2$ was 6.7 kPa (the highest in their series) but $P\mathrm{O}_2$ was not reported. Overall, the authors concluded that the FEV_1 was a poor predictor of postoperative complications.

Inclusion of patients in our series was based on an FEV_1 $\leqslant$ 1 litre, but the most important risk factors in this selected group appear to be not the spirometric values but the arterial $P\mathrm{O}_2$ and the dyspnoea grade. There was no significant correlation between these factors, which suggests their independence. Classification into the dyspnoea grades is partly subjective except that there can be little doubt when a patient is dyspnoeic at rest (Grade 4). Peak flow rate and FEV_1 showed the expected close relationship, and the negative correlation between $P\mathrm{O}_2$ and $P\mathrm{CO}_2$ was consistent with some patients being in respiratory failure.

The end-point in this study has been the use of postoperative ventilation. Others have used death[10] or postoperative pulmonary complications.[9] There were no deaths in the immediate postoperative period in our study other than patient 20 after his third operation, when the cause of death was not primarily respiratory. Postoperative pulmonary collapse and infection were not major problems and did not give rise to concern in any patient.

There can be no certainty in a retrospective study of this nature that the patients who were ventilated in the postoperative period really required ventilation for their survival. However, we can say with certainty that those patients who were not ventilated, the great majority of this series, did not require ventilation, as they made an uneventful recovery. The anaesthetists were aware of the results of the pre-operative respiratory evaluation, although they chose not to ventilate eight out of 11 patients who were dyspnoeic at rest, seven out of nine hypercapnic patients and eight out of 10 patients with FEV_1 less than 0.5 litre. Table 6 lists five patients, all dyspnoeic at rest, with the worst values for arterial $P\mathrm{O}_2$, but who had an uneventful postoperative course without artificial ventilation. The retrospective nature of the study is a virtue in so far as pre-operative pulmonary function testing and anaesthesia itself were purely routine with standards applicable to normal clinical practice.

The analysis of Milledge and Nunn[3] included patients 33–42 of this series and two other patients for whom some risk factors were not determined. They concluded that the best of the factors which they considered was not FEV_1, as had previously been thought, but arterial $P\mathrm{CO}_2$. However, the patients who received artificial ventilation postoperatively had the lowest $P\mathrm{O}_2$ as well as the highest $P\mathrm{CO}_2$ in the series and data from their patients are compatible with the general conclusions of the present augmented series.

Our series, although collected over many years, is too small to draw firm conclusions about the best form of anaesthetic management. However, there seems to be no evidence that opiate premedication is contraindicated, as it was used for premedication in 18 patients, only one of whom required postoperative mechanical ventilation. Similarly, it is not possible to say conclusively from the present study whether regional analgesia is safer than general anaesthesia, although this may well be the case. Thus, no patient in this series received ventilation after spinal or epidural analgesia. Patient 1 received ventilation after a general but not a spinal anaesthetic although the general anaesthetic was given for an upper abdominal procedure. Tarhan *et al.*[11] reported zero mortality in 121 surgical patients with 'moderate to severe chronic lung disease on the basis of clinical and roentgenographic evaluation' who received spinal or epidural anaesthesia, but 35 deaths because of respiratory failure in 464 such patients who received general anaesthesia. They included chronic bronchitis and chronic obstructive pulmonary disease with asthma, bronchitis or emphysema within their definition of chronic lung disease. No results of pre-operative lung function tests were reported.

The concept of a battery of pre-operative pulmonary function tests has been recommended widely, but no clear guidelines have emerged to predict outcome after general surgery which does not involve the lungs. In particular, it is not clear in which patients surgery is contraindicated. It is, in our view, a major shortcoming that insufficient attention has been paid to the predictive value of arterial blood gases, although Tisi[12] pointed out that hypercapnia ($Pa\mathrm{CO}_2$ 6 kPa or 45 mmHg) did not provide an absolute contraindication to surgery. His view is amply supported by the present study in which seven out of nine patients in this category had an uneventful peri-operative period. Roizen[4] has stressed the importance of dyspnoea in pre-operative assessment. Gass and Olsen[13] concluded in a recent review of pre-operative pulmonary function testing that 'there are multiple factors which are highly predictive of respiratory difficulties, but no pre-operative pulmonary function test which absolutely *contraindicates* surgery', a view with which we are in agreement.

In conclusion, we believe that spirometric tests have some value for screening but arterial bloodgas tensions, particularly the $P\mathrm{O}_2$, have much greater predictive value. This value should be considered in relation to the observation of dyspnoea at rest. In no patient in our series was surgery contraindicated.

References

1. SCHWABER JR. Evaluation of respiratory status in surgical patients. *Surgical Clinics of North America* 1970; **50**: 637–44.

2. Benumof JL, Alfery DD. Pulmonary function testing. In: Miller RD, ed. *Anesthesia* Vol. 2. New York: Churchill-Livingstone, 1981: 1363–77.
3. Milledge JS, Nunn JF. Criteria of fitness for anaesthesia in patients with chronic obstructive lung disease. *British Medical Journal* 1975; **3:** 670–3.
4. Roizen MF. Preoperative evaluation of patients with diseases that require special preoperative evaluation and intraoperative management. In: Miller RD ed. *Anaesthesia* Vol. 1. New York: Churchill-Livingstone, 1981: 21–93.
5. Cotes JE. *Lung function*, 3rd edn. Oxford; Blackwell.
6. Nunn JF. *Applied Respiratory Physiology*, 3rd edn. London: Butterworths, 1987: 225 and 270.
7. Scott DL. Anaesthetic experiences in 1,300 major geriatric operations. *British Journal of Anaesthesia* 1961; **33:** 354–70.
8. Fowkes FGR, Lunn JN, Farrow SC, Robertson IB, Samuel P. Epidemiology in anaesthesia III: Mortality risk in patients with coexisting physical disease. *British Journal of Anaesthesia* 1982; **54:** 819–25.
9. Stein M, Koota GM, Simon M, Frank HA. Pulmonary evaluation of surgical patients. *Journal of the American Medical Association* 1962; **181:** 765–70.
10. Mittman C. Assessment of operative risk in thoracic surgery. *American Review of Respiratory Diseases* 1961; **84:** 197–207.
11. Tarhan S, Moffitt EA, Sessler AD, Douglas WW, Taylor WF. Risk of anesthesia and surgery in patients with chronic bronchitis and chronic obstructive pulmonary disease. *Surgery* 1973; **74:** 720–6.
12. Tisi GM. Preoperative evaluation of pulmonary function. Validity, indications, and benefits. *American Review of Respiratory Diseases* 1979; **119:** 293–310.
13. Gass GD, Olsen GN. Preoperative pulmonary function testing to predict postoperative morbidity and mortality. *Chest* 1986; **89:** 127–35.

Anaesthesia, 1988, Volume 43, pages 552–553

Absorption of buccal morphine

A comparison with slow-release morphine sulphate

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Summary

The absorption of buccal morphine was compared with that of slow-release morphine sulphate in human volunteers. Morphine concentration was assayed by high pressure liquid chromatography in serum samples obtained at intervals up to 8 hours after administration of morphine 20 mg. Similar mean maximum concentrations were obtained by either route, but the mean time to maximum concentration was longer after buccal than after enteral administration.

Key words

Analgesics; morphine.
Drug administration; oral, buccal.

Buccal morphine is a recently developed formulation which is claimed to have a pharmacokinetic profile similar to that of intramuscular morphine. It has been reported that mean plasma morphine concentration increases more quickly after intramuscular than after buccal administration to a slightly earlier, slightly higher peak value, but that buccal morphine exhibits a greater area under the curve to 8 hours (AUC_8), which arises from a slower decline in plasma concentration.[1,2]

The clinical impression of relative efficacy in a study which compared buccal with intramuscular morphine as premedication,[3] was in accord with the lesser bioavailability to 90 minutes of buccal morphine, but the authors commented upon the marked variability of response to buccal morphine between patients. This may reflect individuals' different sensitivity to opioids, but there was considerable variation in tablet persistence time on the buccal mucosa, and this suggests that there may have been a variable rate of drug absorption. Furthermore, a recent study,[4] which compared serum concentrations after administration of buccal morphine 25 mg or intramuscular morphine 10 mg, failed to show any resemblance between the pharmacokinetic profiles of buccal and intramuscular morphine.

The present investigation was conducted to compare the absorption of buccal morphine and enteral slow-release morphine sulphate (MST-Continus, Napp).

Methods

The investigation compared serum morphine concentrations achieved after administration of buccal morphine 20 mg (two 10 mg tablets) or MST 20 mg (two 10 mg tablets) on separate occasions, one week apart, to a group of five volunteers. Investigations were performed with the informed consent of the subjects and after approval of the Hospital Ethics Committee. All volunteers were healthy individuals; none was taking other medication, and all were fasted during the studies.

Blood samples were withdrawn from each subject immediately before, and then at intervals of 30, 60, 90, 120, 180, 240, 360 and 480 minutes after, morphine administration. Blood was collected into siliconised glass tubes through an indwelling peripheral venous cannula (Wallace 16 g 2Y–Can), allowed to clot, and then centrifuged to facilitate collection of serum. Serum samples were deep-frozen for subsequent analysis of morphine concentration by high pressure liquid chromatography (HPLC) as previously reported.[4] The extraction (method II) and chromatographic procedure was that described by Todd, Muldoon and Watson,[5] with some minor adjustments to volumes and concentrations of buffers and solvents. Note was made of the length of time for which buccal tablet residue persisted on the buccal mucosa.

Results

Demographic data are presented in Table 1. Mean serum morphine concentration-time profiles obtained after buccal

Table 1. Demographic data. Values expressed as mean (SD), (n = 5).

Age, years	23.0 (0.6)
Height, m	1.65 (0.05)
Weight, kg	60.2 (5.9)

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Table 2. Values, mean (SD), of C_{max}, t_{max} and AUC_8 after administration of morphine 20 mg buccally and as slow-release morphine sulphate (MST) to human volunteers ($n = 5$).

	C_{max} ng/ml	t_{max} minutes	AUC_8 ng min/ml
Buccal	9.1 (2.6)	408 (66)	1615 (548)
MST	9.6 (1.8)	138 (40)	2277 (729)

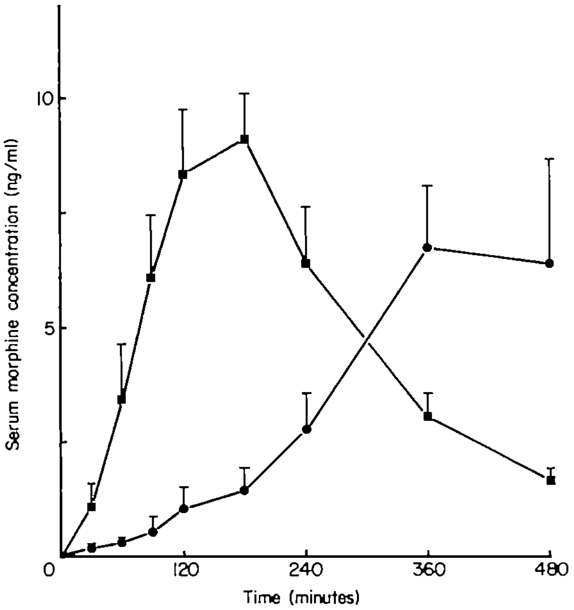

Fig. 1. Change in serum morphine concentration, mean (SEM), with time after administration of buccal morphine 20 mg, ●; or MST 20 mg, ■; ($n = 5$).

and enteral administration are shown in Fig. 1. Mean values of maximum concentration (C_{max}) were 9.1 and 9.6 ng/ml; mean values of time to maximum concentration (t_{max}) were 408 and 138 minutes, respectively. Mean values of AUC_8 after buccal and enteral administration were 1615 and 2277 ng min/ml respectively (Table 2), and the mean systemic availability of buccal morphine relative to that of MST in the first 8 hours after administration was 71%. Individual values of AUC_8 are shown in Table 3. Mean buccal tablet persistence time was 356 (SD 86) minutes. Maximum serum morphine concentration after buccal administration was found in the first blood sample withdrawn after disappearance of the tablet in every subject.

Discussion

Serum morphine concentration increased more slowly after buccal morphine than after MST administration (Fig. 1). Similar mean C_{max} values were achieved with the two formulations, but mean t_{max} was considerably longer after buccal morphine than after MST (Table 2). This finding confirms our recent demonstration[4] that buccal morphine does not produce a serum concentration-time profile similar to that of intramuscular morphine.

Mean t_{max} for buccal morphine was 408 minutes, and it is therefore not possible to comment about the final bioavailability of the preparation. However, AUC_8 was greater after enteral than after buccal administration in four of the five subjects (Table 3). The mean systemic availability of morphine in the first 7 hours after the administration of MST has been estimated to be 18.3%.[6] Our calculation of the availability of buccal morphine relative to that of MST at 8 hours as 71% suggests that the systemic availability of buccal morphine in the first 7 to 8 hours after administration is in the order of 13%. The interindividual variation in buccal tablet persistence times, and the standard deviation of 66 minutes in t_{max} values for buccal morphine, support the impression of variable rate of absorption after buccal morphine administration.[3]

Table 3. Area under the serum morphine concentration—time curve to 8 hours (AUC_8) in five human volunteers after the administration of buccal morphine or MST 20 mg.

Subject	AUC_8 ng min/ml Buccal	MST
1	1092	2305
2	1197	1609
3	1410	2885
4	2017	1483
5	2356	3102

A hard, dry, biconvex tablet placed in the buccal sulcus associates it with a variable period of instability in location until it becomes sufficiently dampened to stick firmly to the mucosa. The surface area of contact between tablet and mucosa at this stage is dependent upon the topography of the mucosal surface immediately adjacent to the tablet. Tablets which stick tenuously on a convexity of the gum might be expected to show different morphine release characteristics from those which quickly establish a large surface area of contact with both gingival and buccal mucosa and dissolve more rapidly. This sort of variation between individuals might also occur within an individual on different occasions.

We have shown[4] that we measure similar morphine concentrations and profile with time after intramuscular morphine as do Bell *et al.*,[2] although the HPLC methods differ in our respective laboratories. We are therefore unable to explain the discrepancy in our respective findings concerning buccal morphine absorption, unless their practice of moistening buccal tablets before administration to facilitate adherence to the buccal mucosa significantly alters the performance characteristics of the preparation. This possibility should be examined. Meanwhile we are of the opinion that, in its present state of development, buccal morphine does not exhibit the reliable absorption characteristics previously suggested.[2]

References

1. Bardgett D, Howard C, Murray GR, Calvey TN, Williams NE. Plasma concentration and bioavailability of a buccal preparation of morphine sulphate. *British Journal of Clinical Pharmacoloty* 1984; **17**: 198P–9P.
2. Bell MDD, Mishra P, Weldon BD, Murray GR, Calvey TN, Williams NE. Buccal morphine—a new route for analgesia? *Lancet* 1985; **1**: 71–3.
3. Fisher AP, Vine P, Whitlock J, Hanna M. Buccal morphine premedication. A double-blind comparison with intramuscular morphine. *Anaesthesia* 1986; **41**: 1104–11.
4. Fisher AP, Fung C, Hanna M. Serum morphine concentrations after buccal and intramuscular morphine administration. *British Journal of Clinical Pharmacology* (in press).
5. Todd RD, Muldoon SM, Watson RL. Determination of morphine in cerebrospinal fluid and plasma by high-performance liquid chromatography with electrochemical detection. *Journal of Chromatography* 1982; **232**: 101–10.
6. Vater M, Smith G, Aherne GW, Aitkenhead AR. Pharmacokinetics and analgesic effect of slow-release oral morphine sulphate in volunteers. *British Journal of Anaesthesia* 1984; **56**: 821–7.

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Recovery after single-breath halothane induction of anaesthesia in daycase patients

A comparison with thiopentone

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Summary

A single-breath technique of inhalational induction of anaesthesia allows intravenous induction agents to be avoided. We have investigated recovery from anaesthesia in 40 daycase patients, using tests of psychomotor function. Patients anaesthetised with inhalational induction awaken earlier than those who receive thiopentone, but not significantly earlier. There were no significant differences in postoperative psychomotor function between patients who received thiopentone and those who had inhalational inductions. Single-breath halothane, nitrous–oxide, oxygen induction is an alternative to intravenous induction in cooperative adults, but does not confer significant benefits in terms of recovery.

Key words

Anaesthetics, volatile; halothane.
Anaesthetics, intravenous; thiopentone.

Inhalational induction of anaesthesia in adults, which employs a single-breath technique[1] with halothane and oxygen, is faster than conventional techniques of inhalational induction, because it produces a more rapid rise in alveolar halothane concentration.[2] The addition of nitrous oxide to the mixture further reduces induction time, by decreasing the alveolar concentration of halothane required to induce anaesthesia,[3] and by means of the second gas effect.[4,5] This technique is a safe and practicable alternative to intravenous induction in cooperative adults.[6]

Thiopentone is almost completely metabolised by the liver; it has a long terminal half-life[7] and is associated with a prolonged hangover effect. The avoidance of thiopentone may increase the speed of recovery from anaesthesia, which would be of particular benefit to daycase patients.[8] We have used tests of psychomotor function to assess recovery from anaesthesia in unpremedicated daycase patients, and to compare single-breath halothane induction with thiopentone.

Methods

Forty patients who underwent check cystoscopy as day cases gave informed consent, and were admitted to the study, which was approved by the hospital ethics committee. All were aged between 18–65 years, and ASA grade 1–3. No patients were included who had taken any psychotropic medication within 72 hours, or had had a halothane anaesthetic within the previous 3 months, or in whom an anaesthetic longer than 20 minutes was anticipated. All patients were unpremedicated, and were allocated randomly to receive either single-breath halothane induction or thiopentone. Anaesthetics were conducted by two of us (J.G.L.S. and E.P.McK.), and psychomotor tests by one of us (J.J.N.), who was unaware of the anaesthetic technique employed.

Each patient undertook four tests on admission to the ward. The critical flicker frequency (CFF) is an index of the effect of centrally acting depressants.[9] Choice reaction time (CRT)[10] was recorded as the mean of 20 times, using a serial five-choice test. Digit span and letter deletion tests were also performed. Practice runs were performed with all tests to minimise learning effects. These tests were undertaken before and repeated 1, 2 and 4 hours after, operation.

Monitoring was started in the anaesthetic room with a continuously displayed electrocardiograph, and automatic oscillometric measurement of blood pressure (Dinamap) recorded every 60 seconds. A 23-gauge cannula was inserted into a vein. Anaesthesia was induced either by single-breath

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halothane or with thiopentone 4 mg/kg and maintained with nitrous oxide, oxygen and halothane in all cases. The time from when the vital capacity breath was taken or the start of the thiopentone injection to loss of the lash reflex was noted. The anaesthetic technique was standardised by decreasing the inspired halothane concentration from the level used for induction to the maintenance level of 1% in set increments at standard time intervals after induction. The halothane was turned off as the cystoscope was withdrawn and the nitrous oxide as the patient was taken out of the lithotomy position. Indices of early recovery were timed from the point at which nitrous oxide was discontinued.

Three simple tests of awakening were conducted in the recovery room. The times after anaesthesia were recorded when the patient opened his eyes to command, could give his own name correctly, and perform a simple task correctly, in this case 'show me your left thumb'. All patients took home a questionnaire which enquired about the acceptability of the method of induction, anaesthetic morbidity and the time at which they felt completely recovered from anaesthesia. The Mann–Whitney *U* test was applied to all data.

Results

Forty patients were studied; 20 received single-breath halothane induction and 20 thiopentone. The demographic data are similar in both groups (Table 1). The mean time of induction was 102 seconds with halothane and 63 seconds with thiopentone. Changes in pulse rate and blood pressure were similar, with a mean decrease in systolic blood pressure of 15 mmHg in either group. The mean duration of anaesthesia was 12.9 minutes in the halothane group and 12.3 minutes in the thiopentone group. The times to awakening and the performance of simple tasks are shown in Table 2. These times are shorter for patients in the halothane group, but the difference does not reach significance. Critical flicker fusion threshold is the mean of the critical flicker frequencies measured with increasing and decreasing rates of flicker. The data are shown in Table 3. There are no significant differences between groups. Choice reaction time (Table 4), letter deletion performance (Table 5) and digit span (Table 6) also show no significant differences between groups. Replies to the questionnaire (Table 7) show that the average time after anaesthesia when patients felt completely recovered was longer for those who had received inhalational induction than thiopentone, but this difference also failed to reach statistical significance. Sixteen out of 19 who returned questionnaires (84%) found inhalational induction acceptable.

Table 1. Demographic data. Age and weight expressed as mean (SD).

	Halothane	Thiopentone
Age, years	55.4 (14.7)	53.5 (13.7)
Weight, kg	70.9 (10.6)	70.5 (12.6)
Male:female ratio	15:5	15:5

Table 2. Recovery from anaesthesia. Values expressed as mean (SD).

	Halothane	Thiopentone
Time to open eyes, seconds	321 (147)	486 (270)
Time to give own name, seconds	360 (151)	525 (265)
Time to obey command, seconds	366 (149)	532 (269)

Table 3. Critical flicker fusion thresholds. Values expressed as mean (SD).

CFFT, Hz	Halothane	Thiopentone
Before operation	29.12 (2.85)	30.33 (2.50)
1 hour after operation	28.92 (2.97)	29.37 (3.32)
2 hours after operation	28.31 (2.82)	29.34 (3.59)
4 hours after operation	28.63 (2.87)	29.55 (2.49)

Table 4. Choice reaction times. Values expressed as mean (SD).

CRT, ms	Halothane	Thiopentone
Before operation	664 (133)	691 (81)
1 hour after operation	705 (142)	725 (134)
2 hours after operation	646 (106)	645 (70)
4 hours after operation	635 (995)	610 (72)

Table 5. Letter deletion performances. Values expressed as mean (SD).

Letter deletion score	Halothane	Thiopentone
Before operation	17.1 (4.99)	18.2 (4.01)
1 hour after operation	21.6 (6.39)	21.8 (3.24)
2 hours after operation	13.9 (5.13)	12.7 (4.35)
4 hours after operation	13.4 (5.49)	12.9 (4.23)

Table 6. Digit span. Values expressed as mean (SD).

Digit span	Halothane	Thiopentone
Before operation	6.05 (1.13)	6.66 (1.24)
1 hour after operation	6.27 (1.07)	6.29 (0.99)
2 hours after operation	5.78 (1.90)	6.72 (1.23)
4 hours after operation	6.32 (1.25)	6.50 (1.15)

Table 7. Data from questionnaire.

	Halothane	Thiopentone
Number of questionnaires returned	19	19
Number (%) of patients who considered induction technique acceptable	16 (84)	19 (100)
Mean time to feeling completely recovered, hours (SD)	7.7 (8.6)	3.6 (5.6)

Discussion

This study confirms that inhalational induction of anaesthesia using a single-breath technique is a safe and practical alternative to intravenous induction in cooperative adult patients. It is rapid, and most patients find it acceptable. Patients anaesthetised by this means are awake sooner after anaesthesia than those given thiopentone; they become wide awake and ready to return to the ward almost immediately after they have opened their eyes, and this was remarked upon by the staff of the recovery ward. However, the difference in recovery times is not statistically significant.

The prolonged hangover associated with thiopentone is particularly undesirable in daycase surgery, and much effort has been devoted to the development of induction agents with shorter elimination half-lives. Inhalational induction provides an alternative method to avoid barbiturate induction agents. Critical flicker fusion threshold is sensitive to the effects of barbiturates,[11] but the decreases in CFFT were very small in both groups and were not statistically significant. This contrasts markedly with a study of CFFT in daycase patients premedicated with benzodiazepines, in whom decreases in CFFT of between 4 and 5 Hz were observed.[12]

Choice-reaction time, digit span and letter-deletion tests also failed to show any significant difference in recovery between patients who received thiopentone and those who did not. Information from the questionnaire also showed no significant difference between groups, which suggests that thiopentone is not primarily responsible for delayed recovery in patients who have also received nitrous oxide and halothane.

We conclude that, while single-breath inhalational techniques offer an alternative to intravenous induction, no positive benefit to recovery can be shown. The routine use of halothane in patients who undergo repeat cystoscopies may be unwise, because of the possibility of hepatotoxicity[13] after repeated exposure. Isoflurane and enflurane are less suited to this technique, since they have pungent aromas, and are more irritant and less potent than halothane. This technique may therefore not be suitable for repeated use.

References

1. Ruffle JM, Latta WB, Snider MT. Single breath halothane oxygen induction in man. *Anesthesiology* 1982; **57:** A461.
2. Ruffle JM, Snider MT. Onset of hypnosis with halothane induction using single breath, triple breath and conventional techniques. *Anesthesiology* 1984; **61:** A498.
3. Saidman LJ, Eger EI II. Effect of nitrous oxide and of narcotic premedication on the alveolar concentration of halothane required for anesthesia. *Anesthesiology* 1964; **25:** 303–306.
4. Epstein RM, Rackow H, Salanitre E, Wolf GL. Influence of the concentration effect on the uptake of anesthetic mixtures: the second gas effect. *Anesthesiology* 1964; **25:** 364–371.
5. Stoelting RK, Eger EI II. An additional explanation for the second gas effect: a concentrating effect. *Anesthesiology* 1969; **30:** 273–277.
6. Wilton NCT, Thomas VL. Single breath induction of anaesthesia, using a vital capacity breath of halothane, nitrous oxide and oxygen. *Anaesthesia* 1986; **41:** 472–476.
7. Morgan DJ, Blackman GL, Paull JD, Wolf LJ. Pharmacokinetics and plasma binding of thiopental. I: Studies in surgical patients. *Anesthesiology* 1981; **54:** 468–473.
8. Editorial. Inhalational induction of anaesthesia—new inspiration? *Lancet* 1986; **2:** 84.
9. Smith JM, Misiak H. Critical flicker frequency (CFF) and psychotropic drugs in normal human subjects. A Review. *Psychopharmacology* 1976; **47:** 175–182.
10. Scott WAC, Whitwam JG, Wilkinson RT. Choice reaction time. A method of measuring postoperative psychomotor performance decrements. *Anaesthesia* 1983; **38:** 1162–1168.
11. Hindmarch I. Psychomotor function and psychoactive drugs. *British Journal of Clinical Pharmacology* 1980; **10:** 189–209.
12. Nightingale JJ, Norman J. A comparison of midazolam and temazepam for premedication of day case patients. *Anaesthesia* 1988; **43:** 111–3.
13. Committee on Safety of Medicines. *Current Problems. Number 18*. September 1986.

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Midwive's assessment of the upper sensory level after epidural blockade

M. J. T. JONES, D. G. BOGOD, G. A. D. REES AND M. ROSEN

Summary

The ability of midwives to assess accurately the level of epidural blockade after a short period of instruction was examined. Seventy-two midwives estimated the upper level bilaterally in 100 patients, by detection of the loss of sensation to a cold stimulus. The midwife and anaesthetist were in complete agreement over the level of block in 71.5% of cases; the midwife overestimated the height of the block in 9.5% of cases, and underestimated in 19%. The midwife underestimated by three spinal segments in 1.5% of cases, and never by more. The technique was acceptable to patients and midwives alike. This procedure should enable safe management of obstetric analgesia, whoever administers top-ups; accurate detection of a block that recedes below therapeutic levels should facilitate earlier top-ups and thus reduce pain for the patient in labour.

Key words

Analgesia; obstetric.
Anaesthetic techniques, regional; epidural.

Midwives are permitted by their National Board rules to administer a prescribed bolus of local anaesthetic (the top-up) through an epidural catheter, after the first injection by an anaesthetist, to maintain analgesia during labour. The decision to top-up is made when the mother complains of returning pain. The only check on accidental intrathecal injection is obvious respiratory difficulty or hypotension when the top-up is administered. This is unsatisfactory and has led to occasional serious complications. The assessment of the level of blockade is an important precaution against continuation of an accidental intrathecal injection, so it is essential that the level before, and after, top-up should be assessed accurately.

The present trial assesses the ability of the midwife to determine the upper sensory level of the block after a short period of simple instruction by an anaesthetist. The ultimate aim would be to develop a safe technique for centres in which midwifery staff carry out the top-up procedure.

Method

The duty obstetric anaesthetist administered the top-up when clinically indicated, and positioned the mother appropriately during routine management of epidural analgesia in labour. Thirty minutes later the midwife who attended the mother was instructed by the anaesthetist how to assess the upper level of the block. It was explained that at the upper limit of the epidural block the mother would perceive a difference in sensation caused by movement of an ice-cube over the skin. The midwife was told to move the ice-cube lightly up the left side of the mother's body from groin to neck and to ask her to indicate when she was aware of the cold from the ice-cube. This level was indicated with a skin marker. The procedure was then repeated on the right side. The anaesthetist then followed the same method and finally recorded the dermatome levels of both assessments. The grade of both the midwife and anaesthetist were recorded, as were any comments from the participants (mother, anaesthetist and midwife).

Results

One hundred patients were assessed by both a midwife and an anaesthetist during the study. Seventy-two midwives and twenty-four anaesthetists, of different grades, took part on a varying number of occasions (Table 1).

The midwives and anaesthetists were in complete agreement on the level of the block (71.5%), or were within one spinal segment (a further 17%) on the majority of occasions (Fig. 1). The greatest variation was three segments and the number of times the assessment differed by two or three segments was small (9.5% and 2% respectively). Midwives overestimated the level in 9.5% of measurements, and underestimated it on 19% of occasions.

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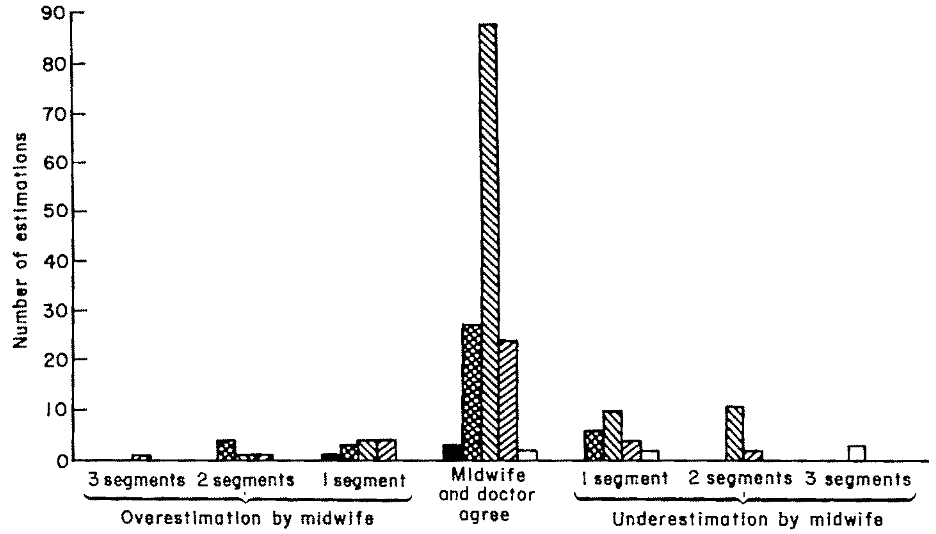

Fig. 1. Difference in assessment of level of block by midwives and anaesthetists. ■, Nursing officer; ▩, Sister; ▨, Staff midwife; ■, Student midwife; □, State enrolled nurse.

Table 1. Grades of midwives and anaesthetists who assessed the blocks.

	n	% grades	% measurements
Grade of midwife			
Nursing officer	2	2.7	2
Sister	17	23.6	20
Staff midwife	37	51.4	58
Student midwife	14	19.4	18
State enrolled nurse	2	2.7	2
Grade of anaesthetist			
Senior registrar	3	12.5	6
Registrar	18	75.0	87
Senior house officer	3	12.5	7

Overestimation may be regarded as a safe measurement in clinical practice and underestimation as a potentially unsafe measurement. Eleven percent of underestimates by the midwives were within one spinal segment, 6.5% within two, and on only 1.5% of occasions did the midwife's assessment of the block underestimate by three spinal segments, and none by more. None of the doctors who participated reported any difficulty teaching the technique, and the midwives expressed none about application of the assessment. No mother found the use of ice-cubes distressful, although several who had had epidural blockade during a previous labour commented: 'this is better than having pins stuck into you'.

Discussion

The increased use of epidural analgesia in labour requires more time from an anaesthetist to provide an obstetric pain relief service. Midwives are allowed as a consequence of this, in many obstetric units, to manage and top-up an established epidural, although always with careful instruction and supervision.[1] Maternal satisfaction with epidural block is generally reported to be high,[2–5], but episodes of unsatisfactory analgesia during labour can occur as the block wears off and before a top-up takes effect,[3] sometimes due to delay in its administration. The problem of such periods of inadequate analgesia has to some extent been improved by the use of a continuous epidural infusion[6–8] but this method still requires the administration of top-ups, although these may be reduced in number. It is desirable that a safe method to assess the level of the block is used before and after the top-up to exclude potentially dangerously high levels of analgesia. It is also important not to allow the analgesia to recede too far before administration of the top-up; the assessment of a sensory level anticipates fading of analgesia.

It is useful to have an easy, rapid and accurately repeatable method to assess the level of analgesia that is acceptable to the mother. There was close agreement in this series of assessments between doctor and midwife on the level of blockade and on only three out of 200 occasions did the midwife underestimate the upper level of the blockade by three segments. It is possible that an unnecessary dose of local anaesthetic may be given, if applied to a labour ward in which midwives administered the top-ups and assessed the upper level of the block as the sole guide to a need for top-ups. However, there is usually a clinical indication for the top-up, such as the perception of discomfort, or even pain, by the mother which would indicate that the upper level of the block had receded to at least T_{11}. We recommend that assessment be carried out every 2 hours and a top-up given if the level of block is inadequate (below T_{10} on either side), to decrease the number of occasions on which the block recedes to the point that a mother becomes distressed before a top-up takes effect. This is also the interval between assessments recommended during epidural infusions[9] in order to detect inadvertent intrathecal infusion. This system may be successfully used by midwives as well as anaesthetists, if measurements of the sensory level are made in conjunction with clinical assessment. The instruction given to the midwives was minimal; a more detailed, repeated and continued instruction would make near-perfect accord possible.

Acknowledgments

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References

1. Crawford JS. Some maternal complications of epidural analgesia for labour. *Anaesthesia* 1985: **40**: 1219–25.
2. Hanson B, Matouvskova-Hanson A. Continuous epidural analgesia for vaginal delivery in Sweden. Report of a nationwide inquiry. *Acta Anaesthesiologica Scandinavica* 1985: **29**: 712–5.
3. Morgan BM, Rehor S, Lewis PJ. Epidural analgesia for uneventful labour. *Anaesthesia* 1980: **35**: 57–60.
4. Holdcroft A, Bevan DR, Morgan M. First year of an obstetric epidural service. *British Journal of Clinical Practice* 1974: **28**: 238–41.
5. Crawford JS. The second thousand epidural blocks in an obstetric hospital practice. *British Journal of Anaesthesia* 1972: **44**: 1277–87.
6. Bogod DG, Rosen M, Rees GAD. Extradural infusion of 0.125% bupivacaine at 10 ml h^{-1} to women during labour. *British Journal of Anaesthesia* 1987: **59**: 325–30.
7. Taylor HJC. Clinical experience with continuous epidural infusion of bupivacaine at 6 ml per hour in obstetrics. *Canadian Anaesthetists' Society Journal* 1983: **30**: 277–85.
8. Abboud TK, Afrasiabi A, Sarkis F, Daftarian F, Nagappala S, Noueihed R, Kuhnert BR, Miller F. Continuous infusion epidural analgesia in parturients receiving bupivacaine, chloroprocaine, or lidocaine—maternal, fetal, and neonatal effects. *Anesthesia and Analgesia* 1984: **63**: 421–8.
9. Li DF, Rees GAD, Rosen M. Continuous extradural infusion of 0.625% or 0.125% bupivacaine for pain relief in primigravid labour. *British Journal of Anaesthesia* 1985: **57**: 264–70.

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Peri-operative dreaming and awareness in children

A. J. HOBBS, G. H. BUSH AND D. Y. DOWNHAM

Summary

Dreaming under anaesthesia was investigated in a prospective study of 120 day case paediatric patients, aged 5–17 years, who underwent a variety of surgical procedures. Patients were anaesthetised using the 'Liverpool technique' of paediatric anaesthesia (nitrous oxide–oxygen–relaxant). No patient reported awareness, but 23 of 120 patients (19%) reported dreams. Analysis of the data revealed that the choice of muscle relaxant, (nondepolarising or depolarising) had a statistically significant effect on the incidence of dreaming ($p < 0.05$). It is suggested that the technique of intermittent intravenous suxamethonium may result in increased muscle spindle discharge and cause cerebral arousal and an increased incidence of dreaming.

Key words

Anaesthesia, paediatric.
Complications; dreaming, awareness.

Dreaming and awareness under anaesthesia have been studied extensively in adults.[1–3] Controlled ventilation with muscle relaxants and no adjuvants in unpremedicated patients is associated with a high incidence of dreaming, and also awareness.[2–4] However, few studies have involved children. McKie and Thorp[5] found that in 202 children aged 7–11 years, 12 (6%) reported dreams and 10 (5%) had partial recall. Pledger[6] reported no cases of awareness, and an 11% incidence of dreaming, in a prospective survey of 431 children aged 8 years or more.

The present investigation differs from these two studies[5,6] in two respects. Firstly, younger children are included, as a pilot study revealed that young children could answer questions if sufficient time were taken to win their confidence and care taken to avoid leading questions. Secondly, the growth in popularity of daycase surgery has increased the number of unpremedicated or lightly premedicated patients, and hence the possibility of awareness.

Dreaming is defined as any experience (excluding awareness) which a patient *thought* occurred between the induction of anaesthesia and the first moment of consciousness after anaesthesia. Children who report dreams cannot say precisely when dreaming occurred; many have a postoperative sleep during which dreaming could occur and be indistinguishable from peranaesthetic dreaming. This problem has been noted in adults.[2] Furthermore, the pre-induction 'patter' in the anaesthetic room may give rise to hypnagogic phenomena which are remembered as dreams.

Patients and methods

Consecutive patients scheduled to undergo elective daycase surgery at Alder Hey Children's Hospital over a 3-month period, and in whom either suxamethonium chloride or atracurium besylate was used for muscle relaxation, were studied. Patients were either unpremedicated or received a weight-related dose of 'Ponstan Mix' (mefenamic acid, trimeprazine and atropine) one hour before induction of anaesthesia. The 'Liverpool technique' of paediatric anaesthesia was used in all cases. This comprised an intravenous induction, the use of a muscle relaxant to allow tracheal intubation, and controlled hand ventilation using an Ayre's T-piece with Jackson–Rees modification. The patient's lungs were ventilated with the Jackson–Rees bag to an end tidal carbon dioxide tension of 4.5–5.0 kPa measured with a Datex infrared carbon dioxide analyser. Anaesthesia was maintained with 70% nitrous oxide in 30% oxygen, and increments of muscle relaxants and analgesic drugs were given as required peroperatively. Volatile agents were not used.

Six anaesthetists were involved in the study. One anaesthetist assessed the patient's mood with a linear analogue scale which ranged from 0 (very calm) to 100 mm (very agitated). Anaesthesia was then induced with sodium thiopentone 5 mg/kg and the chosen muscle relaxant. The choice of either suxamethonium or atracurium depended upon the proposed duration of anaesthesia; intermittent

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suxamethonium was used for short procedures. The lungs were ventilated manually with 70% nitrous oxide and 30% oxygen with a face mask and Ayre's T-piece until muscle relaxation occurred, when the trachea was intubated. The patient was transferred into the operating theatre with the fresh gas inlet of the Ayre's T-piece crimped to allow continued ventilation, and anaesthesia was then maintained as before. Residual neuromuscular blockade was reversed if necessary after surgery, with atropine and neostigmine. The trachea was extubated while the patient breathed either 100% oxygen or 50% oxygen in nitrous oxide.

The patient remained in the recovery area after extubation until fully awake, and then returned to the ward. All patients were interviewed by A.H. just before discharge. A standard questionnaire (modified from Brice, Hetherington and Utting,[2] and McKie and Thorp[5]) was used and the questions were incorporated into a conversation with the child. The data were analysed using SPSSX, a statistical software package. Discrete variables were analysed by the Chi-square test and continuous variables by Anova tests. Armitage's test for trends was also used.[7]

Results

One hundred and twenty patients (79 male) were studied. The mean age of the patients was 9 years, with a range of 5–17. Fifty-seven children received no premedication. Detailed information is shown in Table 1. Neither the age, sex nor incidence of reported dreams at home correlated with peroperative dreams. However, the degree of sedation, as assessed by the anaesthetist before induction, did relate to the incidence of reported dreams; children who reported dreams were assessed as calmer (95% confidence level for the mean). This table also shows that this reduction in mood score is not due to the sedative effects of 'Ponstan Mix'.

No patient reported awareness, and 19% reported dreams. There were no relationships between the surgical specialty or operative field and the incidences of reported dreams. The relationships between dreaming and premedication, muscle relaxant administration and peroperative movement are shown in Table 3. The use of 'Ponstan Mix' did not alter the incidence of dreams. However, the choice of muscle relaxant did produce a significant difference; 24% of patients who received an intermittent suxamethonium technique reported dreams compared to 9% of those who received atracurium. Peroperative spontaneous muscle movement (excluding suxamethonium-induced muscle fasciculations) was assessed in 104 patients. No correlation was found between patient movement and dreaming for either muscle relaxant alone or for the group as a whole. Eleven patients (of whom four had an intermittent suxamethonium technique) received peroperative potent analgesic agents (morphine, fentanyl or pentazocine); one of these patients reported dreams.

Table 2. Details of operative procedures.

	Total	Reported dreams
Operative specialty		
ENT	70	14 (20%)
Dental	5	—
Ophthalmology	1	—
Orthopaedic	11	1 (9%)
Plastic	6	2 (33%)
General surgery	27	6 (22%)
Total	120	23 (19%)
Operative field		
Head and neck	77	15 (20%)
Rest of body	43	8 (19%)
Total	120	23

Table 3. Effects of premedication, choice of muscle relaxant and peroperative movement on incidence of reported dreams.

	Total	Reported dreaming	Significance
Premedication effect			
'Ponstan mix'	63	10 (16%)	
No premedication	57	13 (23%)	NS
Total	120	23 (19%)	
Muscle relaxant used			
Suxamethonium	85	20 (24%)	
Atracurium	35	3 (9%)	$p < 0.05$
Total	120	23	
Peroperative movement			
Nil	54	6 (11%)	
Slight	39	8 (23%)	
Moderate	11	2 (18%)	NS
Not assessed	16	7	
Total	120	23	

NS Not significant.

Table 1. Pre-operative data.

	Total	Reported dreams	No reported dreams
Males	79	16 (20%)	
Females	41	7 (17%)	
Total	120	23 (19%)	
Incidence of home dreams remembered			
never	10	4 (40%)	
1–2/week	76	16 (21%)	
nightly	34	3 (9%)	
Total	120	23	
	mean		
Age, years (SD)	9.0	7.7 (1.3)	9.3 (0.6)
Mood score, mm, (SD)	49	42 (5)	50 (3)
Mood score, mm, (SD) vs premedication	49	'Ponstan mix' 48 (4)	No premedication 50 (4)

Discussion

There was no report of awareness or operation-related dreams in this prospective study of 120 patients anaesthetised with the 'Liverpool technique' of paediatric anaesthesia. This corresponds with Pledger's findings at the same institution 24 years ago, but differs from the findings of McKie and Thorp[5] who studied 202 children and reported a 5% incidence of factual recall. Seven of these patients received a relaxant–narcotic sequence, two received halothane by positive pressure ventilation and one breathed halothane spontaneously; premature withdrawal of the volatile agent was cited as the cause in one case.

The incidence of reported dreams was 19% in the present study, compared with 11% in the studies of Pledger[6] and McKie and Thorp.[5] We sought factors that differed in our study which might account for the increased reporting of dreams. We found, like Pledger, that the sex of the child and the use of a premedicant (Table 3) did not affect the incidence of reported dreams. Likewise the surgical specialty, operative site (head and neck, or rest of body) (Table 2), age, incidence of remembered dreams at home (Table 1) and the use of potent analgesics peroperatively had no statistical influence at the 5% level.

The mood of the patient as assessed before induction revealed that patients who reported dreams were assessed as calmer and this calmness was not a function of the premedication (Table 1). Agitation appears therefore not to predispose to reporting dreams. The most significant factor which related to dreams was the choice of muscle relaxant (Table 3). Twenty (24%) patients who received suxamethonium reported dreams compared to 3 (9%) of those who received atracurium. We thought initially that this was due to increased peroperative movement, as has been reported by others;[2,5] however, our data did not verify this. A review of the literature provided a possible explanation. Suxamethonium causes profound muscle spindle discharge[8] due to intrafusal fibre contraction.[9] This discharge produces an intense electroencephalogram (EEG) arousal pattern.[10,11] We postulate that this effect in the lightly anaesthetised patient may cause an increased incidence of dreaming. If this is true, pretreatment with a nondepolarising neuromuscular blocking agent may reduce the incidence of reported dreams by the prevention of muscle spindle discharge and therefore the EEG arousal response.[10,11] Clearly, a further trial is needed to test this hypothesis. Furthermore, EEG arousal patterns are seen on skin incision in anaesthetised patients who breathe halothane spontaneously;[10,11] this may explain the incidence of dreaming in McKie and Thorp's study. Pledger did not record the muscle relaxant used in his series of 431 inpatients; the choice would have been between suxamethonium and curare. However, the use of a heavy narcotic premedication (in 63% of patients) suggests either that relatively few patients received an intermittent suxamethonium technique, or that narcotics modify the response.

Acknowledgments

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References

1. Hutchinson R. Awareness during surgery. A study of its incidence. *British Journal of Anaesthesia* 1961; **33:** 463–9.
2. Brice DD, Hetherington RR, Utting JE. A simple study of awareness and dreaming during anaesthesia. *British Journal of Anaesthesia* 1970; **42:** 535–41.
3. Harris TJB, Brice DD, Hetherington RR, Utting JE. Dreaming associated with anaesthesia: the influence of morphine premedication and two volatile adjuvants. *British Journal of Anaesthesia* 1971; **43:** 172–8.
4. Utting JE. Awareness during surgical operations. In: Atkinson RS, Langton Hewer C, eds. *Recent advances in anaesthesia and analgesia*, 14. Edinburgh: Churchill Livingstone, 1982: 105–19.
5. McKie BD and Thorp EA. Awareness and dreaming during anaesthesia in a paediatric hospital. *Anaesthesia and Intensive Care* 1973; **1:** 407–14.
6. Pledger HG. Observations on some aspects of general anaesthesia in children. MD Thesis Durham 1963; 97–104.
7. Armitage P. Tests for linear trends in proportions and frequencies. *Biometrics* 1955; **2:** 375–86.
8. Granit R, Skoglund S, Thesleff S. Activation of muscle spindles by succinylcholine and decamethonium. Effects of curare. *Acta Physiologica Scandinavica* 1953; **28:** 134–51.
9. Smith CM, Eldred E. Mode of action of succinylcholine on sensory endings of mammalian muscle spindles. *Journal of Pharmacology and Experimental Therapeutics* 1961; **131:** 237–42.
10. Mori K, Iwabuchi K, Fujita M. The effects of depolarizing muscle relaxants on the electroencephalogram and the circulation during halothane anaesthesia in man. *British Journal of Anaesthesia* 1973; **45:** 604–10.
11. Oshima E, Shingu K, Mori K. E.E.G. activity during halothane anaesthesia in man. *British Journal of Anaesthesia* 1981; **53:** 65–72.

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Intra-articular bupivacaine for pain relief after arthroscopic surgery of the knee joint in daycase patients

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Summary

A randomised double-blind study was conducted to compare the influence on postoperative pain of equal volumes of one of two concentrations of bupivacaine (0.25%, 0.5%), or saline 0.9%, injected into the knee joint after arthroscopy. The results showed that intra-articular bupivacaine had no significant analgesic effect in either concentration. Plasma bupivacaine concentrations were measured 20 minutes after injection in order to determine the extent of systemic absorption.

Key words

Anaesthetic techniques; local.
Surgery; arthroscopy.

Arthroscopy of the knee joint is a common operation which is performed often on daycase patients at our hospital. One problem inherent in this form of daycase surgery is uncertainty about the extent of postoperative pain and requirements for analgesia which follow. It has been recommended that procedures which may produce severe postoperative pain should be excluded from daycase surgery and that local anaesthesia should be used where appropriate.[1]

Routh[2] reported that 41% of patients experienced pain after daycase surgery, but did not comment on the severity of the pain or the nature of the surgery; 2.5% of his patients required a home visit from the general practitioner to provide analgesia. Hughes[3] compared intra-articular bupivacaine 0.25% (50 mg) with femoral nerve block in hospitalised patients for arthroscopy and found the latter to be superior. In the present study, we set out to compare analgesia in patients who had undergone arthroscopy followed by bupivacaine 0.5% (100 mg), bupivacaine 0.25% (50 mg), or saline 0.9%.

Methods

The study was approved by the hospital ethics committee. Forty male patients (ASA 1 or 2) aged 18–50 years gave informed consent and were instructed in the use of visual analogue pain scales before surgery. All patients were unpremedicated and received a standard anaesthetic technique. Anaesthesia was induced with a sleep dose of thiopentone 2.5% and maintained with halothane in a mixture of nitrous oxide 70% in oxygen. We were prepared to use an alternative volatile agent should this have been advisable in the light of any patient's previous exposure to halothane, but this did not prove to be necessary. Monitoring included automated blood pressure recording and electrocardiography. Patients were observed closely for any premonitory sign of bupivacaine toxicity. No such sign was encountered.

The hospital pharmacy allocated the patients randomly to one of three groups and provided a sterile 20 ml solution of bupivacaine 50 mg (Group A), bupivacaine 100 mg (Group B) or saline 0.9% (Group C). The solution was injected through the arthroscope by the surgeon at the end of the procedure when as much as possible of the irrigating saline had been drained from the knee joint. The surgery was undertaken between 1400 and 1530 hours in the majority of cases. All patients were allowed home, escorted, by 1700 hours.

Linear analogue pain scores were recorded 20 minutes after the conclusion of surgery by one of the authors (K.A.M.), and by the patient at 1600 and 2200 on the day of surgery, and in the morning and at lunchtime on the following day. The patients were also asked to record any sleep disturbance because of pain as well as their analgesic requirements, in the form of Co-proxamol (dextropropoxyphene and paracetamol) two tablets up to 4-hourly. A

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single blood sample was taken 20 minutes after injection of the solution for measurement of plasma bupivacaine concentration.

Differences between pairs of groups were analysed using the nonparametric Mann–Whitney U Test.

Results

Thirty-nine of the 40 patients returned completed questionnaires with linear analogue pain charts. Median visual analogue pain scores for each group at the five different assessment times are shown in Table 1. There were no significant differences between any pair of groups at any time.

Table 1. Median visual analogue pain scores (10-cm scale).

	Group A (n)	Group B (n)	Group C (n)
Immediate	2.0 (13)	1.7 (11)	3.0 (15)
1600 hours	1.7 (11)	2.6 (9)	3.2 (12)
2200 hours	1.2 (13)	4.3 (11)	2.5 (15)
Morning	0.8 (13)	2.5 (11)	1.0 (14)
Noon	0.6 (13)	1.7 (11)	0.3 (14)

The number of Co-proxamol tablets taken by patients in each group ranged from none to eight. Median values were Group A: 0.46, B: 2.13, C: 0.44. These differences were not significant. More patients in Group B (73%) required analgesics than in Group A (46%) or Group C (43%). However, these differences were not significant (Fisher's Exact Probability Test).

Twenty-eight per cent of patients reported a disturbed night's sleep due to pain in the operation site. There were no significant differences between groups.

Plasma bupivacaine concentrations were higher in Group B (median 850 µg/litre; range 390–1200 µg/litre) than in Group A (median 479 µg/litre; range 121–725 µg/litre) ($U = 12$, $p < 0.02$).

Discussion

This study shows that direct injection of bupivacaine 50 mg or 100 mg into the knee joint after arthroscopy provides little analgesia. The plasma levels were all below reported toxic plasma bupivacaine concentrations in man (2–4 µg/ml).[4,5] This might support a case for use of a higher concentration of bupivacaine, but the authors do not propose to undertake such a study. Small molecules are known to traverse the synovium rapidly to reach the joint capsule, which is perforated by articular vessels and nerve endings.[6] Plasma bupivacaine concentrations in the present study confirm this. The lack of analgesia may suggest that the source of pain after arthroscopy is outside the capsule of the knee joint.

Goold[7] commented in a review of daycase surgery that local anaesthesia wears off to reveal previously masked pain and may increase the difficulty of anticipating the degree of pain before the patient is allowed home. Our study demonstrated incidentally that it is not possible to predict relative severity of pain between patients who had simple arthroscopy and those who also had arthroscopic meniscectomy. We noted that almost one third of our patients had experienced pain which was not relieved satisfactorily by simple analgesia as afforded by Co-proxamol tablets. It may be that patients who undergo such procedures should have the benefit of a lengthier stay in hospital, even overnight, in order to afford them a higher quality of postoperative analgesia.

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References

1. Ogg TW. Use of anaesthesia: implications of day case surgery and anaesthesia. *British Medical Journal* 1980; **281:** 212–4.
2. Routh GS. Day care surgery under general anaesthesia in a purpose built unit. *Anaesthesia* 1979; **34:** 809–11.
3. Hughes DG. Intra-articular bupivacaine for pain relief in arthroscopic surgery. Anaesthesia 1985 **40:** 821.
4. Jorfeldt L, Lofstrom B, Pernow B, Persson B, Wahren J, Widman B. The effect of local anaesthetics on the central circulation and respiration in man and dog. *Acta Anaesthesiologica Scandinavica.* 1968; **12:** 153–69.
5. Tucker GT, Mather LE, Clinical pharmacokinetics of local anaesthetics. *Clinical Pharmacokinetics* 1979; **4:** 241–78.
6. Warwick R, Williams PL, eds. *Gray's Anatomy,* 35th edn. Edinburgh: Longman, 1973: 394–7.
7. Goold JE. Anaesthesia for day case surgery; a review. *Journal of the Royal Society of Medicine* 1983; **76:** 415–20.

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Suxamethonium induced myalgia and the effect of pre-operative administration of oral aspirin

A comparison with a standard treatment and an untreated group

C. McLOUGHLIN, G. A. NESBITT AND J. P. HOWE

Summary

Eighty-four fit, unpremedicated patients who presented for routine surgery and received a standard anaesthetic technique were allocated randomly to three equal groups. Group 1 received tubocurarine 0.05 mg/kg before induction of anaesthesia. Group 2 received soluble aspirin 600 mg orally one hour before surgery, while Group 3 received no pretreatment. Aspirin prophylaxis produced a significant reduction in the incidence of subsequent suxamethonium-induced myalgia and the improvement was similar to that achieved with tubocurarine pretreatment. Pre-operative oral administration of aspirin effectively reduces muscle pains and avoids many of the complications associated with pretreatment with non-depolarising agents.

Key words

Analgesis; salicylates, aspirin.
Neuromuscular relaxants; suxamethonium, tubocurarine.

Generalised myalgia after suxamethonium administration is a frequent and troublesome complication.[1–4] The pains most commonly affect the neck, shoulders, chest and subcostal region and are manifest usually during the first and second postoperative days, particularly in ambulant patients.[1] Women are affected more frequently than men and the incidence is low in children and in the elderly.

A number of prophylactic measures have been employed to reduce the incidence of suxamethonium pains; the most common is pretreatment with a small dose of a non-depolarising muscle relaxant before induction of anaesthesia.[3,5–8] This technique is not without its problems however, and larger doses of suxamethonium than normal may be required. Difficulties with tracheal intubation and prolonged muscle relaxation may be encountered.[3,7,9,10] Aspirin is a nonsteroidal anti-inflammatory drug (NSAID) used in the treatment of musculoskeletal disorders. It inhibits the synthesis of prostaglandins, and has an analgesic and antipyretic action in addition to its anti-inflammatory effects.[11]

This study compares the effect of the pre-operative oral administration of aspirin on suxamethonium-induced myalgia with a standard treatment, and an untreated group.

Patients and methods

ASA 1 and 2 patients aged 16–65 years, who weighed 40–100 kg and presented for elective surgery, where orotracheal intubation was considered desirable, were studied. Patients gave informed verbal consent and ethics committee approval was obtained. Exclusion criteria included anticoagulant therapy, history of peptic ulceration and known sensitivity to aspirin and its derivatives. Patients were unpremedicated and allocated randomly to one of three equal groups. Group 1 patients received tubocurarine 0.05 mg/kg 3 minutes before induction of anaesthesia. Group 2 patients received soluble aspirin 600 mg orally one hour before induction and Group 3 received no pretreatment. Anaesthesia was induced with thiopentone 4–5 mg/kg. Patients in Group 1 were administered suxamethonium 1.5 mg/kg intravenously to facilitate intubation of the trachea. Patients in Groups 2 and 3 received suxamethonium 1.0 mg/kg intravenously. The larger dose of suxamethonium given to patients in Group 1 was in accordance with dosage recommendations to achieve comparable muscle relaxation.[12] Intubating conditions in the three groups were recorded on a four-point scale as excellent, satisfactory, fair or poor.[13]

Anaesthesia was maintained with 67% nitrous oxide in oxygen supplemented with isoflurane. A non-depolarising muscle relaxant of appropriate duration of action was employed when controlled ventilation of the lungs was required. Patients were visited at 24 hours and 48 hours postoperatively and questioned by a second anaesthetist, who was unaware of the treatment group, about the degree of any myalgia. This was graded[3] as nil, no pain; mild,

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pain confined to one site and not causing disability; moderate, affecting more than one site, but not causing disability; severe, affecting more than one site and causing disability, for instance, getting out of bed, turning the head. Postoperative mobility and analgesic requirements were recorded, and the results analysed with the Mann–Whitney *U* test.

Results

Three groups with 28 people in each were studied. The groups were of similar age, weight and sex (Table 1). The spectrum of operation types was broadly comparable; most patients were ambulant and none was receiving analgesia by the second postoperative day. Three patients (in the tubocurarine group) were discharged within 24 hours of operation and were not followed up. These were excluded from the study.

Table 1. Physical characteristics of patients.

	Tubocurarine	Aspirin	Untreated
Males:females	11:14	10:18	14:14
Age, years (SEM)	40 (3.2)	40 (2.9)	37 (2.9)
Weight, kg (SEM)	65 (3.1)	65 (3.1)	70 (2.0)

The range of muscle pains is shown in Fig. 1. The incidence of myalgia in the untreated group was 57%. Pretreatment with tubocurarine reduced the incidence to 36% while in the group pretreated with aspirin, six patients (21%) complained of postoperative muscle pains. The reduction in incidence of myalgia in the aspirin group compared with the untreated group was significant ($p < 0.01$). Fewer patients pretreated with aspirin experienced muscle pains compared with the tubocurarine group; but the difference was not statistically significant. In considering the total number of patients studied, 43.5% of the females and 31.4% of the males experienced myalgia postoperatively, but these results were not statistically different.

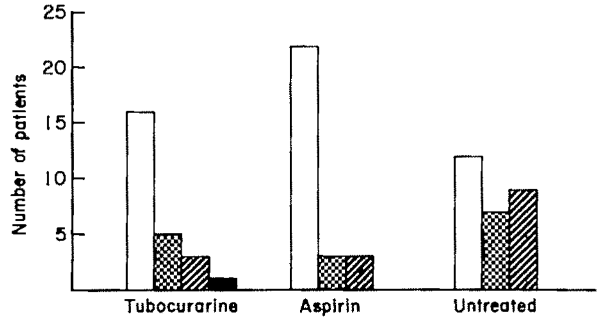

Fig. 1. Frequency of myalgia after administration of suxamethonium in three groups of patients who received tubocurarine, aspirin and no pretreatment. □, nil; ▨, mild; ■, moderate; ■, severe.

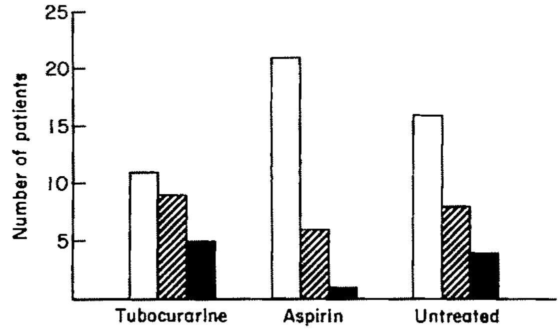

Fig. 2. Intubation conditions after administration of suxamethonium in three groups of patients who received tubocurarine, aspirin and no pretreatment. □, excellent; ■, adequate; ■, fair or poor.

Intubating conditions are represented in Fig. 2; they are similar throughout the three groups. Fewer patients in the tubocurarine pretreated group (44%) were recorded as having excellent intubating conditions than in the untreated group (64%). This difference is not statistically significant: intubating conditions were poor in four patients in the tubocurarine group and in three patients in the untreated group.

Discussion

Postoperative myalgia associated with the administration of suxamethonium is a common clinical problem. Many techniques have been employed in an attempt to reduce its incidence, the most commonly used and successful of which had been pretreatment with a small dose of a non-depolarising muscle relaxant before induction. Problems encountered with this method are difficulty with intubation and prolonged neuromuscular paralysis.[3,7,9,14] Takki *et al.* showed that a dose of suxamethonium 1.5 mg/kg was required to achieve adequate intubation conditions after pretreatment with a non-depolarising drug.[12] Our study confirms that a larger dose of suxamethonium is required for patients pretreated with tubocurarine; intubation conditions were less favourable in this group compared with the untreated group, although the results did not achieve statistical significance. Incidence of myalgia is said to be increased in females,[1] but this finding was not confirmed.

The NSAIDs have been used in anaesthesia to reduce postoperative pain and therefore opiate requirements.[15,16] This study shows that pretreatment with oral aspirin significantly reduces postoperative muscle pain associated with suxamethonium administration. Fewer patients pretreated with aspirin experienced pain compared to those pretreated with tubocurarine. Comparison of the two treatments, while not showing statistically significant differences, suggests that aspirin pretreatment is at least as successful as pretreatment with tubocurarine in the prevention of suxamethonium-induced myalgia. Advantages of oral aspirin include ease of administration, availability and low cost. More importantly, aspirin does not interfere with intubating conditions. These findings are supported by a recent study by Naguib *et al.* with an intravenous preparation, lysine acetyl salicylate.[17]

The aetiology of suxamethonium-induced myalgia is not fully elucidated. Local muscle trauma caused by asynchronous muscle bundle contractions may mimic the pain associated with unaccustomed exercise.[1,18] Raised lactic-acid levels in the muscle as a cause of pain has been suggested by König[19] while raised serum potassium levels have also been cited as a factor in its aetiology by Mayrhofer.[20] Collier suggested that the primary event may be the disruption of delicate muscle spindles, since the pain was most severe in those muscles with greatest spindle density.[21] A decrease in serum calcium one minute after suxamethonium administration has been noted and Collier postulated that influx of calcium into the muscle caused vigorous and damaging contractions.[22]

We suggest that there may be parallels between this calcium influx after suxamethonium, with that observed in experimentally-induced muscle damage. Jackson and Jones,[23] using electrically stimulated isolated muscle preparations, showed that calcium uptake into the muscle occurred and that this is bound to calmodulin causing activation of phospholipase A2 (Fig. 3). This in turn produced a rise in lysophospholipids and free fatty acids. The latter include arachidonic acid, which is the precursor of the prostaglandin series of compounds. The prostaglandins may therefore represent one line of attack on cellular mechanisms, and thus there may be a rationale for use of prostaglandin inhibitors to halt the genesis of cellular damage.[24]

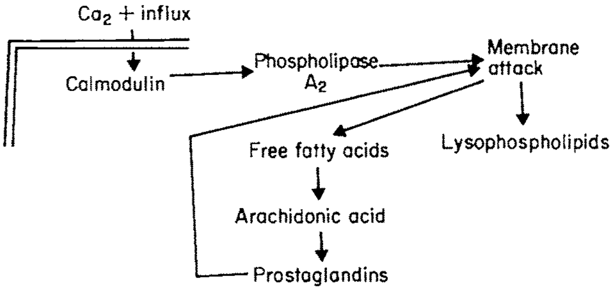

Fig. 3. Flow diagram which illustrates the role of calcium influx into muscle and possible mechanisms of cellular damage.

In summary, the most successful technique for the prevention of the onset of suxamethonium-induced myalgia has been pretreatment with non-depolarising muscle relaxants. As stated in the discussion, they are not free of problems. We believe that the promising results of this study provide an alternative approach with prophylactic NSAIDs in the reduction of the troublesome problem of suxamethonium-induced myalgia.

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References

1. Newman PTF, Loudon JM. Muscle pain following administration of suxamethonium: The aetiological role of muscular fitness. *British Journal of Anaesthesia* 1966; **38:** 533–40.
2. Foster CA. Muscle pains that follow administration of suxamethonium. *British Medical Journal* 1960; **2:** 254–5.
3. White DC. Observations on the prevention of muscle pains after suxamethonium. *British Journal of Anaesthesia* 1962; **34:** 332–5.
4. Durant NN, Katz RL. Suxamethonium. *British Journal of Anaesthesia* 1982; **54:** 195–208.
5. Chestnutt WN, Lowry KG, Dundee JW, Pandit SK, Mirakhur RK. Failure of two benzodiazepines to prevent suxamethonium-induced muscle pain. *Anaesthesia* 1985; **40:** 263–9.
6. Verma RS, Chatterji S, Mathur N. Diazepam and succinylcholine-induced muscle pains. *Anaesthesia and Analgesia ... Current Researches* 1978; **57:** 295–7.
7. Wig J, Bali IM. Relation of precurarization to suxamethonium to provide ease of intubation and to prevent post-suxamethonium muscle pains. *Canadian Anaesthetists' Society Journal* 1979; **26:** 94–8.
8. Erkola O, Salmenperä A, Kuoppamäki R. Five non-depolarizing muscle relaxants in precurarization. *Acta Anaesthesiologica Scandinavica* 1983; **27:** 427–32.
9. Bennetts FE, Khalil KI. Reduction of post-suxamethonium pain by pretreatment with four non-depolarizing agents. *British Journal of Anaesthesia* 1981; **53:** 531–6.
10. Hartman GS, Fiamengo SA, Riker WF. Succinylcholine: mechanism of fasiculations and their prevention by d-tubocurarine or diphenylhydantoin. *Anesthesiology* 1986; **65:** 405–13.
11. Bevan JA. Essentials of Pharmacology, 2nd edn. Hagerstown: Harper and Row, 1976.
12. Takki S, Kauste A, Kjellberg M. Prevention of suxamethonium-induced fasciculations by prior dose of d-tubocurarine. *Acta Anaesthesiologica Scandinavica* 1972; **16:** 230–4.
13. Clarke RSJ, Mirakhur RK, Bali IM, Dundee JW. Intubating conditions with Org. NC45: a comparison with suxamethonium and pancuronium. in: Prys Roberts C, Vickers MD, eds. *Cardiovascular measurement in anaesthesiology. (European Academy of Anaesthesiology, Vol 2.)* Berlin: Springer-Verlag, 1982: 86–90.
14. Bruce DL, Downs JB, Kulkarni P, Capan L. Precurarization inhibits maximal ventilatory effort. *Anesthesiology* 1984; **61:** 618–21.
15. Collier D St J, Pain JA. Recital indomethacin for control of postoperative pain. *British Medical Journal* 1983; **287:** 1799–1800.
16. Dundee JW, McAteer E. Intravenous salicylates for post-operative pain. *Lancet* 1981; **I:** 154.
17. Naguib M, Farag H, Magbagbeola JAO. Effect of pre-treatment with lysine acetyl salicylate on suxamethonium-induced myalgia. *British Journal of Anaesthesia* 1987; **59:** 606–10.
18. Newham DJ, Mills KR, Quigley BM, Edwards RHT. Pain and fatigue after concentric and eccentric muscle contractions. *Clinical Science* 1983; **64:** 55–62.
19. König, W. Über Beschwerden nach Anwendung von Succinylcholin. *Anaesthesist* 1956; **5:** 50–3.
20. Mayrhofer O. Die Wirksamkeit von d-Tubocurarin zur Verhütung der Muskelschermzen nach Succinylcholin. *Anaesthesist* 1959; **8:** 313.
21. Collier CB. Dantrolene and suxamethonium. *Anaesthesia* 1979; **34:** 152–8.
22. Collier CB. Suxamethonium pains and early electrolyte changes. *Anaesthesia* 1978; **33:** 454–61.
23. Jackson MJ, Jones DA, Edwards RHT. Experimental skeletal muscle damage: the nature of calcium-activated degenerative processes. *European Journal of Clinical Investigation* 1984; **14:** 369–74.
24. Rodemann HP, Waxman L, Goldberg AL. The stimulation of protein degredation in muscle by Ca^{2+} is mediated by prostaglandin E^2 and does not require the calcium-activated protease. *Journal of Biological Chemistry* 1981; **257:** 8716–23.

Anaesthesia, 1988, Volume 43, pages 568–569

CASE REPORT

Common peroneal nerve palsy

A complication of coronary artery bypass grafting surgery

Y. HATANO, T. ARAI, H. IIDA AND J. SONEDA

Summary

Two cases of common peroneal nerve palsy after coronary artery bypass grafting surgery are described and the possible causative mechanisms are discussed.

Key words

Complications; peripheral nerve injury, common peroneal nerve.
Surgery; cardiac.

The incidence of postoperative peripheral nerve injuries is reported to be high after open heart surgery, probably because of the use of cardiopulmonary bypass.[1,2] Such lesions after open heart surgery have shown some predilection for the upper half of the body; the brachial plexus is the most frequent site[2,3] and others include the phrenic nerve,[4,5] recurrent laryngeal nerve and facial nerve.[2] We describe transient common peroneal nerve palsy in two patients with hypercholesterolaemia, who underwent coronary artery bypass grafting (CABG) surgery in the supine position with their legs slightly flexed and externally rotated on thigh pads, for the surgical exposure of the saphenous vein. This has not previously been reported as a complication of CABG surgery.

Case history

Two male patients, one, a 45-year-old who weighed 56 kg, and the other, a 46-year-old who weighed 60 kg, with familial hypercholesterolaemia, underwent a triple coronary artery bypass operation because of increasing episodes of angina pectoris. Cardiac catheterisation of the two patients revealed 95 to 100% proximal atheromatous occlusion in three arteries. The left ventricular ejection fraction was 0.42 in the first patient and 0.6 in the second. Laboratory findings revealed hypercholesterolaemia in both patients, and impaired glucose tolerance with normal fasting blood glucose levels in the second patient, who had marked cutaneous xanthomata. Neither patient had peripheral neuropathy. Physical examination, which included a neurological examination, was normal.

They were premedicated with hyoscine 0.4 mg, intramuscular morphine 10 mg, and oral diazepam 10 mg. An intravenous line, left radial artery cannulation and insertion of pulmonary artery catheter through the right internal jugular vein were established in the operating room. Anaesthetic management in both patients was essentially the same. Anaesthesia was induced with intravenous diazepam, fentanyl (45 to 50 μg/kg) and pancuronium, and then the patients were intubated. Anaesthesia was maintained with 50% oxygen in air and intermittent doses of fentanyl (total 100 μg/kg) and pancuronium. They were kept in the supine position, after induction of anaesthesia, with the right arm at their side and the left arm abducted at an angle of approximately 90 degrees. Their legs were slightly flexed and externally rotated on foam-rubber thigh pads at a height of approximately 15 cm, for surgical exposure of the saphenous vein. Cardiopulmonary bypass with moderately deep hypothermia (23 to 25 °C) was instituted, about 60 minutes after the start of surgery, with a constant arterial inflow of 2.4 litres/minute/sq m into the ascending aorta. The perfusion pressure measured at the left radial artery ranged from 45 to 50 mmHg during cardiopulmonary bypass, the duration of which was approximately 140 minutes in both patients. Saphenous veins were taken from the left leg. The duration of anaesthesia was 5 hours in the first patient and 6 hours in the second, and in both cases anaesthesia was uneventful. The patients were transfered to ICU after the operation, and their postoperative courses are described below.

Patient one. The patient had been mechanically ventilated for 2 days after operation and remained in bed for another 2 days until the haemodynamic status was stable. He complained of right footdrop and numbness on the dorsum of

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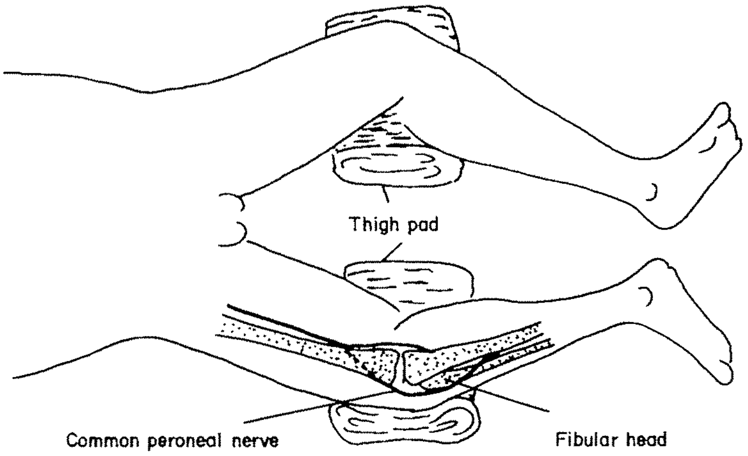

Fig. 1. Schematic diagram of leg positioning for surgical exposure of the saphenous vein in patients who undergo CABG surgery. As illustrated, the common peroneal nerve is stretched by external rotation of the legs and compressed at the level of the fibular head by the thigh pad.

the left foot 4 days after operation. Physical examination revealed paralysis of the muscles of the anterior tibialis, the extensor hallucis longus, the extensor digitorum longus, and the peroneal, and hyperaesthesia of the dorsum of the left foot. A diagnosis was made of bilateral common peroneal nerve palsy. The paralysis and hyperaesthesia in the left foot gradually improved during the next 35 days.

Patient two. The patient's trachea was extubated 2 days after the operation. The postoperative haemodynamic and respiratory course was uneventful but 3 days after the operation the patient complained of bilateral numbness on the dorsum of his feet, which was more profound in the left than in the right. Physical examination revealed bilateral hyperaesthesia and anaesthesia on the medial aspect of the dorsum of the left foot. There was no muscle paralysis. The anaesthesia and hyperaesthesia in both feet gradually subsided over the next 3 months.

Discussion

The principal cause of most peripheral nerve injuries in anaesthetised patients is ischaemia of the nerves, which results primarily from their compression or stretching.[6] Most postoperative common peroneal nerve injuries occur as a result of incorrect leg positioning such as in the lithotomy, sitting, lateral decubitus or supine positions with the use of a fracture table,[1,6,7] all of which lead to compression or stretching of the nerves. Our patients were put in the supine position; the legs were slightly flexed and externally rotated on a knee roll (Fig. 1). This position is unavoidable in CABG surgery to provide access to the saphenous vein, and as a result the common peroneal nerves are slightly stretched and compressed at the level of the fibular head. (It has been suggested that the most frequent cause of injury to the common peroneal nerve is its direct compression at the level of the fibula head because of its superficial location.[1])

We tried to minimise compression against the fibula head by use of soft thigh pads intra-operatively. Other factors, however, might have contributed to nerve ischaemia, such as pre-existing medical disorders and the use of cardiopulmonary bypass. Hypercholesterolaemia existed in both patients and asymptomatic diabetes mellitus in one patient; two disorders that are often complications in ischaemic heart disease patients. Atherosclerosis caused by hypercholesterolamia, as well as polyarteritis nodosa,[2] makes nerves more susceptible to ischaemia. Patients with diabetes mellitus, even asymptomatic, are especially vulnerable to nerve injury during anaesthesia.[8] In addition, cardiopulmonary bypass with low perfusion pressure and haemodilution may induce further hypoxia of the nerves. In such circumstances even minimum stretching or compression may exaggerate the likelihood of ischaemia within the nerve cells.

In conclusion, common peroneal nerve injury, may occur after coronary artery bypass surgery. It is likely that a number of factors are involved but nerve ischaemia is the probable underlying cause.

References

1. Parks BJ. Postoperative peripheral neuropathies. *Surgery* 1973; **74:** 348–57.
2. Keates JRW, Innocenti DM, Ross DN. Mononeuritis multiplex: a complication of open-heart surgery. *Journal of Thoracic and Cardiovascular Surgery* 1975; **69:** 816–19.
3. Honet JC, Raikes JA, Kantrowitz A, Pursel SE, Rubenfire M. Neuropathy in the upper extremity after open-heart surgery. *Archives of Physical Medicine and Rehabilitation* 1976; **57:** 264–7.
4. Kohorst WR, Schonfeld SA, Altmann M. Bilateral diaphragmatic paralysis following topical cardiac hypothermia. *Chest* 1984; **85:** 65–8.
5. Brown KA, Hoffstein V, Byrick RJ. Bedside diagnosis of bilateral diaphragmatic paralysis in a ventilator-dependent patient after open-heart surgery. *Anesthesia and Analgesia* 1985; **64:** 1208–10.
6. Britt BA, Joy N, Mackay MB. Positioning trauma. In: Orkin RK, Cooperman LH, eds. *Complications in anesthesiology.* Philadelphia: J.B. Lippincott, 1983: 647–70.
7. Keykhah MM, Robenberg H. Bilateral footdrop after craniotomy in the sitting position. *Anesthesiology* 1979; **51:** 163–4.
8. Jones HD. Ulnar nerve damage following general anaesthetic. a case possibly related to diabetes mellitus. *Anaesthesia* 1967; **22:** 471–5.

Anaesthesia, 1988, Volume 43, pages 570–572

CASE REPORT

Visual disturbances after spinal anaesthesia

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Summary

A complication in two female patients after spinal anaesthesia for Caesarean section is outlined. Both patients acquired permanent visual disturbances caused by pericentral ring scotomata, a condition not described before.

Key words

Eye; scotomata.
Anaesthetic techniques; spinal.

Hypotension, low back pain and headache are complications of spinal anaesthesia. Rare complications are paresis of cranial nerves,[1] pneumocephalus[2] and subdural haematoma.[3]. We describe two patients with persistent visual disturbances after spinal anaesthesia, a complication not described previously.

Case histories

Case 1

In July 1985 a 29-year-old female was scheduled for Caesarean section in a general hospital, the indications for which were a large child and a small pelvis. Two years before she had undergone a Caesarean section for a similar reason, under general anaesthesia without any complication. Spinal anaesthesia was performed by injection of hyperbaric 0.5% bupivacaine 3.5 ml into the subarachnoid space between L_3 and L_4 through a 22-G needle. Arterial blood pressure decreased from 140/70 mmHg to 60/40 mmHg despite the infusion of crystalloids 1000 ml, lateral tilt, ephedrine 25 mg and calcium-gluconate 1.0 g. By mistake adrenaline 1.0 mg was also given intravenously. The patient developed ventricular fibrillation but immediate defibrillation was successful. Arterial blood pressure increased to 150/110 mmHg; the period of hypotension had been 15 minutes. She was given ketamine 50 mg intravenously after delivery Postoperative haemoglobin was 6.6 mmol/litre. Antithrombotic prophylaxis was given by means of 5000 units heparin subcutaneously. She complained of headache and black spots in both fields of vision from the first postoperative day. Ophthalmoscopy demonstrated small haemorrhages in both macular areas. Visual acuity was 6/6 and 5/6 on the right and left eye respectively 3 days later, and after a week it was 6/6 on both eyes; the macular haemorrhages had disappeared. The patient still complained about black spots, and visual-field examination showed bilateral pericentral scotomata with preservation of central vision within the centre of two degrees. There was no leakage of the macular capillary bed as shown by fluorescein angiography.

The patient was referred to our hospital 4 months later. Visual acuity was 7/6 on both eyes, the media were clear and the macular areas had very mild pigment changes. Field examinations demonstrated bilateral pericentral ring scotomata (Fig. 1). Visual flash-evoked potentials showed normal optic nerve latency times (105 msec). Other ophthalmological and neurological investigations, which included CT-scanning and nuclear magnetic resonance imaging, showed no abnormalities. Her ophthalmic condition was stable a year later.

Case 2

A 30-year-old female was scheduled for Caesarean section in a general hospital. Spinal anaesthesia was performed by injection of hyperbaric amethocaine 16 mg into the subarachnoid space between L_3 and L_4 through a 22-G needle. Arterial blood pressure decreased from 110/80 mmHg to 90/60 mmHg and increased to normal values after ephedrine 10 mg given intravenously. The patient was sedated with diazepam 10 mg, droperidol 5 mg and fentanyl 50 μg intravenously, after childbirth. Arterial blood pressure was stable. The patient complained about headache and black spots in both fields of vision immediately after the procedure. The ophthalmologist could find only pericentral

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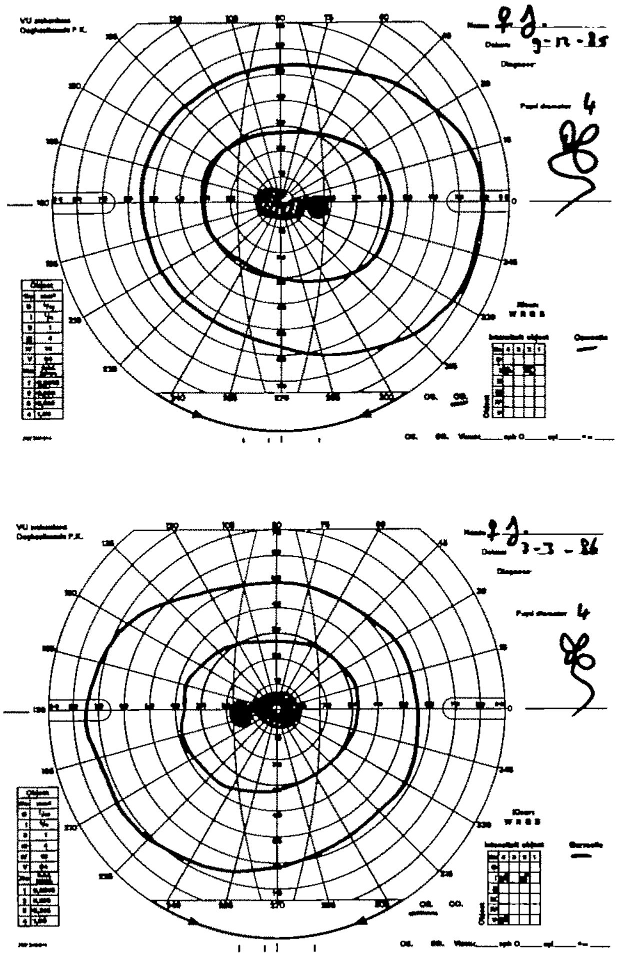

Fig. 1. Pericentral ring scotoma in the right and left eye of case 1 (Goldmann kinetic perimeter).

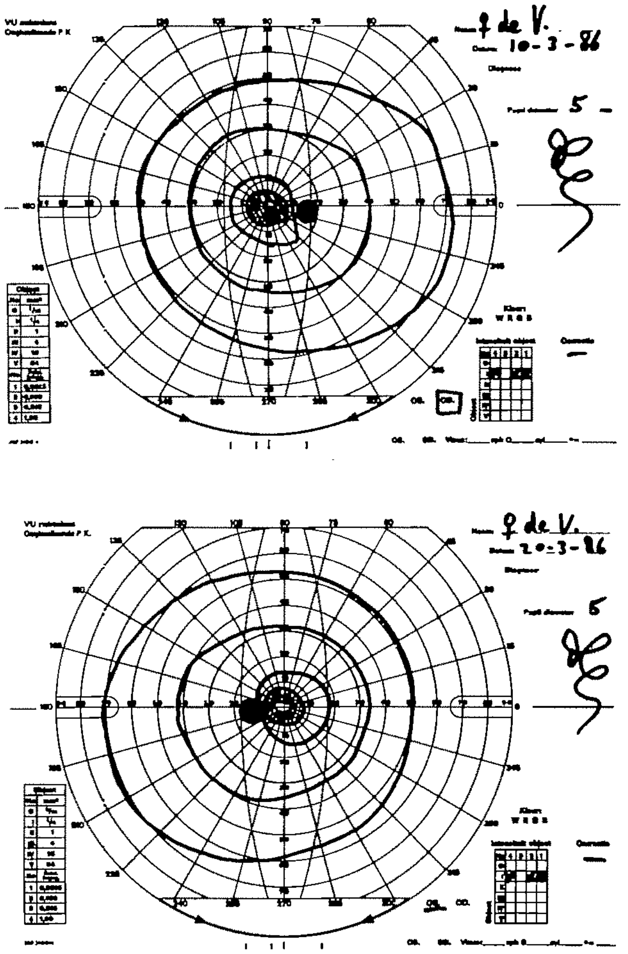

Fig. 2. Pericentral scotoma with preservation of central vision in case 2 (Goldmann kinetic perimeter).

scotomata with preservation of central vision. Visual acuity remained 7/6 on both eyes.

The patient was referred to our hospital a year later. Central visual acuity was still 7/6 on both eyes; fundus examination showed a loss of fovea reflex on both eyes and mild pigment changes, predominantly in the right eye. There was no leakage of the macular capillary bed. Visual field examination showed pericentral ring scotomata in both eyes (Fig. 2). Other ophthalmological and neurological examination, which included CT-scanning, disclosed no abnormalities. The visual field defects were unchanged 4 years after the spinal anaesthesia.

Discussion

Between one and four percent of patients complain about visual disturbances (diplopia, difficulty in accommodation, experience of black spots) combined with headache,[4] after spinal anaesthesia. It has not been suggested that these visual disturbances are permanent, although in our two patients the visual disturbances caused by pericentral bilateral scotomata appear permanent. Ophthalmologists rarely find pericentral bilateral scotomata within 10 degrees with preservation of central vision.[5] However, extensive and thorough visual-field examination is necessary to discover these scotomata. In case 1 the visual-field defect was missed at routine visual screening, and only discovered when the patient insisted on further examinations.

A toxic effect of the local anaesthetic as the aetiological factor is unlikely, because two different drugs were used, both in normal doses. Ischaemia is more likely to be the cause because the macular area in both cases showed pigment changes, and loss of foveal reflex in case 2. Systemic hypoxia probably did not occur, because other signs of hypoxia were lacking and there was no obvious episode of oxygen deprivation during the operation. A low perfusion pressure in the brain from systemic hypotension could be the cause in case 1, but is unlikely in case 2. There were no other symptoms of cerebral damage, as confirmed by CT-scanning in both cases and nuclear magnetic resonance imaging in case 1. Another reason for ischaemia is mechanical: traction on the optic nerve because of decreased intracranial pressure caused by leakage of cerebrospinal fluid. The concurrent presence of postspinal headache supports the generally accepted explanation of cerebrospinal leakage which results in low intracranial pressure. Gravity traction on a cranial nerve results in ischaemia and damage.[6]

We conclude that for patients who complain of black spots after spinal anaesthesia an accurate ophthalmologic examination is indicated.

References

1. WANG LP. Sudden bilateral hearing loss after spinal anaesthesia. A case report. *Acta Anaesthiologica Scandinavica* 1986; **30**: 412–413.

2. Roderick L, Moore DC, Artru AA. Pneumocephalus with headache during spinal anesthesia. *Anesthesiology* 1985; **62:** 690–692.
3. Jonsson LO, Einarsson P, Olsson GL. Subdural haematoma and spinal anaesthesia. *Anaesthesia* 1983; **38:** 144–146.
4. Lanz E, Dick W. *Spinalanaesthesie: Ergebnisse eines Workshops Woelm.* Pharma, Eschwege 1984; 148–149.
5. Stoll MR. Pericentral ring scotoma. *Archives of Ophthalmology* 1950; **43:** 66–91.
6. Vandam LD, Dripps RD. Long-term follow-up of patients who received 10,098 spinal anesthetics. Syndrome of decreased intracranial pressure (headache and ocular and auditory difficulties.) *Journal of the American Medical Association* 1956; **161:** 586-591.

Anaesthesia, 1988, Volume 43, pages 573–577

CASE REPORT

Relapsing polychondritis and the anaesthetist

A. W. HAYWARD AND B. AL-SHAIKH

Summary

The anaesthetic management of a patient with upper airway obstruction secondary to relapsing polychondritis is described. The relevance of this condition to the anaesthetist is discussed.

Key words

Co-existing disease; relapsing polychondritis.

Relapsing polychondritis is a rare disease of unknown aetiology, which most commonly presents in middle age with an equal sex incidence. It is manifested by recurrent and generally progressive inflammation of the cartilaginous portions of the external ear, joints, nose and respiratory tract, as well as recurrent nonchondral inflammation which involves the eye, inner ear and cardiovascular system. An auto-immune mechanism which triggers enzymatic breakdown of the chondroitin matrix in cartilage is thought to be the causative factor.[1]

Patients may require general anaesthesia for a variety of surgical procedures, which include tracheostomy, laryngotracheoplasty and aortic valve replacement. We report the details of a patient with relapsing polychondritis who required general anaesthesia for a tracheostomy, and discuss the implications of this condition for the anaesthetist.

Case history

A 37-year-old obese woman with relapsing polychondritis was referred to the Royal National Throat, Nose and Ear Hospital because of increased shortness of breath thought to be because of the narrowing of her trachea as a result of collapse of the cartilaginous support.

She first presented approximately 3 years before admission with an acute chondritis which affected the ears, and within a few months, also the nasal cartilage. She developed breathlessness soon after this and an attempt was made to perform bronchoscopy using local anaesthetic. Bronchoscopy showed a narrow and inflamed trachea, but the procedure had to be abandoned because the patient developed severe stridor and became cyanosed. Investigations at the time showed a haemoglobin of 9.6 g/dl, an erythrocyte sedimentation rate (ESR) of 125 mm/hour, negative auto-antibodies (apart from weakly positive smooth muscle antibodies) and a normal chest X ray. The patient was treated with a combination of prednisolone and azathioprine which improved both symptoms and haematological findings. She had experienced recurrent attacks of lower respiratory tract infection with increased breathlessness and bronchospasm during the last 18 months. It was decided on admission to hospital that she needed a tracheostomy to secure her airway. This was to be performed under general anaesthesia because it was considered that her obesity and the anatomical abnormality of her airway would make the surgery technically difficult.

Pre-operative assessment

She was hoarse, on examination, with inspiratory and expiratory stridor at rest, but was not distressed or cyanosed. However, her mobility was restricted to moving from her bed to the bedside chair. Her weight was 104 kg and she had a saddle nose and perichondritis of the ears (Figs 1 and 2). There was no abnormality in the cardiovascular system and auscultation of the lungs revealed inspiratory and expiratory wheezes. Lung function tests showed a peak expiratory flow rate of 115 litres/minute (predicted value 539 litres/minute), a forced expiratory volume in one second of 0.94 litres (predicted value 2.73 litres) and a forced vital capacity of 2.81 litres (predicted value 3.45 litres). The haemoglobin was 14.2 g/dl, white blood cell count 13.6 × 10^9/l and ESR 31 mm/hour. Urea and electrolytes, electrocardiograph and chest X ray were normal. High kilovoltage films of the trachea (Fig. 3) showed irregular narrowing in both diameters which did

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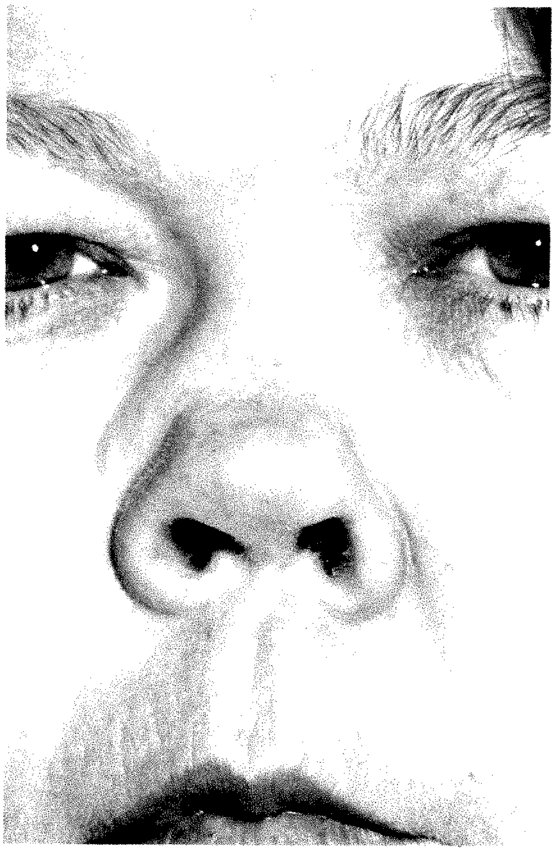

Fig. 1. Anterior view of the face showing the patient's saddle-nose.

not alter with expiration or inspiration. The glottis was thought to be only slightly narrowed.

Anaesthetic technique

Atropine 0.6 mg and hydrocortisone 100 mg administered intramuscularly were given as premedication. Continuous electrocardiographic and oxygen saturation monitoring, and intermittent blood pressure measurements were commenced in the anaesthetic room (and continued in theatre). A 20-gauge cannula was sited in the left arm while preoxygenation was performed. Increments of midazolam 1 mg were given intravenously until she was adequately sedated, as she was extremely anxious. Induction was commenced with 50% oxygen in nitrous oxide plus halothane. It was found difficult to ventilate the lungs by mask once sleep was achieved. However, direct laryngoscopy provided an easy view of the larynx, so suxamethonium 100 mg was given to facilitate intubation. The glottis was extremely small and it was only possible to pass a 3.0 mm plain Magill tracheal tube with the assistance of a metal introducer. The lungs were manually ventilated using a Bain breathing system and atracurium (0.4 mg/kg) was given to provide further muscle relaxation. Anaesthesia was maintained with 50% nitrous oxide, oxygen and halothane (0.5–1%).

Direct laryngoscopy was performed by the surgeon after the tracheostomy. Findings were of an infantile epiglottis with a grossly narrowed larynx because of erythema and oedema. The subglottis and upper trachea were also narrowed. There was some crusting and infection of the entire narrow portion of the upper airway.

The postoperative course was uneventful until 12 days later when the tracheostomy wound broke down and needed to be resutured under general anaesthetic. The tracheostomy tube became displaced on the ward 3 days after this. It was not possible to find the tract, because of the obesity of the patient, and it was therefore decided to refashion the tracheostomy under general anaesthesia. It was found, after induction, that on this occasion a 3.0 mm plain Magill tracheal tube would not pass through the glottis, and so a 14-gauge Harris catheter was used; the patient was ventilated manually with some difficulty with a Bain breathing system. She did well postoperatively and was discharged with the tracheostomy *in-situ* and her relapsing polychondritis controlled on a maintenance dose of prednisolone and azathioprine.

Discussion

Jaksch-Wartenhorst[2] first described the nasal and auricular deformities together with vertigo and hearing loss in 1923. Altherr[3], in 1936, noted the destruction of cartilage in the ears, nose, ribs, joints, larynx and tracheobronchial tree. In 1960 Pearson[1] suggested the term relapsing polychondritis because of the episodic nature of the illness. Diagnostic criteria of the disease were described by McAdam[4] in 1976 and expanded by Damiani[5] in 1979. Clinical manifestations at the time of diagnosis as well as those subsequently seen in one series of 112 patients[6] are shown in Table 1.

Most patients with relapsing polychondritis do not present with symptoms from respiratory tract involvement, although approximately half are found to have disease in this area. Symptoms referrable to the respiratory tract include voice hoarseness, nonproductive cough, sore throat

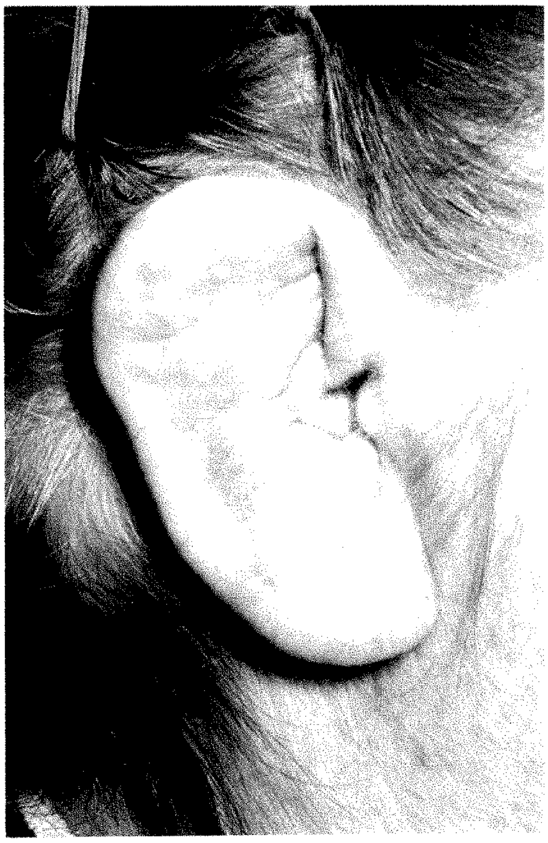

Fig. 2. Lateral view of the head showing one perichondritic ear.

Table 1. Clinical manifestations of relapsing polychondritis.

Clinical manifestations	Distribution of patients Presenting %	 Cumulative %
Auricular chondritis	39	85
Hearing loss	9	26
Vertigo	4	13
Nasal chondritis	24	54
Saddle-nose	18	29
Laryngotracheal symptoms	26	48
Laryngotracheal stricture	15	23
Ocular symptoms	19	51
Arthritis	36	52
Fever	20	39
Skin manifestations	7	28
Aortic regurgitation	0	4
Mitral regurgitation	0	2
Aneurysm	0	4
Increased ESR	74	82
Anaemia	50	55
Increased serum creatinine	7	13
Microhaematuria	15	26
Proteinuria	8	14

and tenderness over the anterior trachea or thyroid cartilage. Dyspnoea and stridor may develop with increasing severity. Episodes of inflammation in cartilage lead initially to swelling which causes narrowing of the glottis, trachea or major bronchi. Healing by fibrosis during the later stages of the disease may lead to permanent narrowing of the airway. Dissolution of tracheal or bronchial cartilage as the disease progresses may cause dynamic collapse of the airway during the different phases of respiration. Our patient presented with biphasic stridor and the obstruction was thought most likely to be in the trachea. However, on laryngoscopy the glottis was found to be extremely narrowed with disease present in the subglottis and trachea. According to McAdam[4] when the obstruction is localised to the glottic or subglottic area respiratory tract symptoms are the presenting feature of the disease, and are usually because of inflammatory swelling. Many patients with tracheal or bronchial obstruction develop recurrent pulmonary infections because of the inability to clear secretions adequately. Respiratory obstruction, with or without infection is responsible for approximately 50 percent of the deaths.[7]

The pulmonary function tests showed a forced vital capacity within the normal range, with markedly reduced forced expiratory volume in one second and peak expiratory flow rate. The expiratory obstruction either reflects premature closure of medium-sized airways, because of loss of cartilaginous support, or fixed narrowing of these airways caused by scarring, or a combination of both. This may also account for the expiratory wheezes heard on auscultation of the lung fields. Assessment of the airway radiologically should include plain X rays and tomography of the neck,[8] in the presence of marked narrowing. Tomography was not performed in our patient and might have alerted us to the degree of narrowing in the glottis. According to Krell,[9] apart from the standard pulmonary function tests, complete evaluation of the airway in relapsing polychondritis should include both inspiratory and expiratory flow/volume curves, even when bronchoscopic

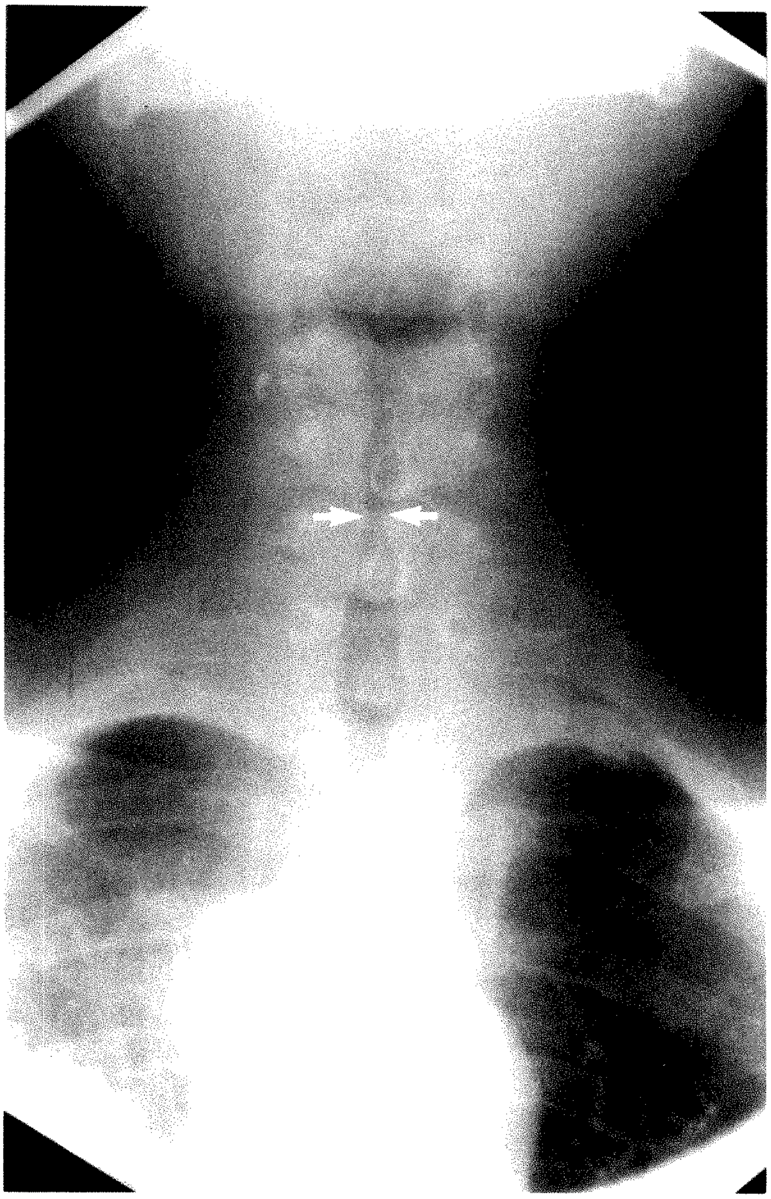

Fig. 3. High KV film of the neck (postero-anterior) which shows narrowing in the trachea (arrowed).

and X ray findings of the airway appear normal. This will assist the functional analysis of the stenosis.

Our patient did not have any cardiovascular abnormalities. Dysrhythmias, heart murmurs and abnormal electrocardiographs were occasionally noted in the early cases of relapsing polychondritis. The most common cardiovascular abnormalities are aortic valve incompetence and aortic aneurysm.[10] It has been reported[11] that in some cases the aortic insufficiency is due to inflammation and destruction of the medial elastic layers of the aortic root with resultant dilatation, but in other reports[12] only cusp involvement was found.

Anaemia and glomerulonephritis are also features of this disease. Our patient was anaemic (9.6 g/dl normochromic normocytic) when first diagnosed in 1983 but her haemoglobin was 14.2 g/dl when seen in our hospital. She had no evidence of renal disease.

Treatment with prednisolone and azathioprine is indicated during the acute stage of relapsing polychondritis. Dapsone has also been shown to be effective but tends to cause side effects.

Conclusion

The most likely surgical procedure in relapsing polychondritis is a tracheostomy. Narrowing of the upper airway and cardiovascular abnormalities are the most life-threatening features of this condition. Expiratory wheezes heard on auscultation of the chest are liable to be related to the condition and be nonreversible. Patients may present with recurrent pneumonias for treatment on the intensive care unit. Anaemia and glomerulonephritis may also be seen. Treatment of relapsing polychondritis during the acute phase is usually with a combination of prednisolone and azathioprine.

Acknowledgments

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References

1. Pearson CM, Kline HM, Newcomer VD. Relapsing polychondritis. *New England Journal of Medicine* 1960; **263**: 51–58.
2. Jaksch-Wartenhorst R. Polychondropathia. *Wiener Archiv für innere Medizin* 1923; **6**: 93–100.
3. Altherr RF. Über einen Fall von systematisierter Chondromalacie. *Virchow's Archiv für pathologische Anatomie und Physiologie und für klinische Medizin* 1936; **297**: 445–79.
4. McAdam LP, O'Hanlan MA, Bluestone R, Pearson CM. Relapsing polychondritis: prospective study of 23 patients and a review of the literature. *Medicine* 1976; **55**: 193–215.
5. Damiani JM, Levine HL. Relapsing polychondritis. Report of ten cases. *Laryngoscope* 1979; **89**: 929–46.
6. Michet CJ, McKenna CH, Luthra HS, O'Fallon WM. Relapsing polychondritis. Survival and predictive role of early disease manifestations. *Annals of Internal Medicine* 1986; **104**: 74–78.
7. Rabuzzi DD. Relapsing polychondritis. *Archives of Otolaryngology*. 1970; **91**: 188–94.
8. Kilman WJ. Narrowing of the airway in relapsing polychondritis. *Radiology* 1978; **126**: 373–6.
9. Krell WS, Staats BA, Hyatt RE. Pulmonary function in relapsing Polychondritis. *American Review of Respiratory Diseases* 1986; **133**: 1120–3.
10. Esdaile J, Hawkins D, Gold P, Freedman SO, Duguid WP. Vascular involvement in relapsing polychondritis. *Canadian Medical Association Journal*. 1977; **116**: 1019–22.
11. Hainer JW, Hamilton GW. Aortic abnormalities in relapsing polychondritis. *New England Journal of Medicine* 1969; **280**: 1166–8.
12. Mestres CA, Igual A, Botey A, Revert L, Murtra M. Relapsing polychrondritis with glomerulonephritis and severe aortic insufficiency surgically treated with success. *Thoracic and Cardiovascular Surgery*. 1983; **31**: 307–9.

Anaesthesia, 1988, Volume 43, pages 578–580

CASE REPORT

Complete heart block during anaesthesia in a patient with sarcoidosis

D. W. THOMAS AND R. A. MASON

Summary

An apparently fit young man with sarcoidosis developed complete heart block during an emergency mastoidectomy. A temporary transvenous pacemaker was inserted, but permanent pacing was required in the postoperative period. The clinical and pathological features of cardiac sarcoidosis are described; complete heart block is the commonest presentation of cardiac involvement. The role of anaesthesia as the precipitating factor in this case is discussed.

Key words

Sarcoidosis.
Complications; complete heart block.

Sarcoidosis is a multisystem granulomatous disorder, most frequently presenting in young adults with bilateral hilar lymphadenopathy, pulmonary infiltration, cutaneous and ocular lesions. Cardiac disease is a less common but well recognised complication of sarcoidosis, and may be due either to granulomatous infiltration of the myocardium itself, or to the effects of pulmonary hypertension secondary to widespread fibrotic changes in the lungs. Complete heart block is the commonest presentation of cardiac sarcoidosis. This complication occurred unexpectedly during emergency ear surgery in an apparently fit young man with probable sarcoidosis.

Case history

A 39-year-old man was admitted for emergency exploration of his left mastoid. Biopsy of an enlarged submandibular gland 4 years before had suggested sarcoidosis, but the Kveim test was negative. The patient had developed some increased reticular shadows in the lung fields over the 2 years that followed, but there was no definite hilar lymphadenopathy. Angiotensin converting enzyme and 24-hour urinary calcium levels were elevated and a diagnosis of sarcoidosis had been presumed, 3 months before admission. The patient was a keen surfer, kept fit by jogging, and had normal pulmonary function tests and electrocardiographs (ECG) at regular outpatient review.

His heart rate was 60 beats/minute and arterial pressure 130/80 mmHg at the pre-operative visit; the chest X ray showed hilar enlargement and increased reticular shadows in both lung fields. A new ECG was not thought necessary because of his recent outpatient attendance less than 3 months before, and his athletic activities. Premedication was with papaveretum 15 mg and hyoscine 0.3 mg. Anaesthesia was induced with thiopentone, tubocurarine and fentanyl and maintained with nitrous oxide, oxygen and enflurane with positive pressure ventilation. Monitoring techniques included ECG, automatic blood pressure measurement, end tidal carbon dioxide and inspired oxygen concentrations, pulse oximetry and a ventilator alarm.

The heart rate dropped suddenly at the beginning of surgery and it was noted that the sinus rhythm at a rate of 60 beats/minute had changed to a rate of 40 beats/minute, with complete atrioventricular dissociation. The patient was treated initially with atropine and isoprenaline; then a temporary transvenous pacemaker was inserted. He required continuous pacing at 60 beats/minute in the immediate postoperative period. There were no intrinsic beats when the underlying cardiac activity was tested, even when the pacemaker rate was reduced to 20 beats/minute. The patient was referred for permanent pacemaker insertion on the 12th postoperative day because of his pacemaker dependence. Echocardiography was normal and it was therefore assumed that the sarcoid infiltration was restricted to the conducting tissue.

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Discussion

There has been no previous report of complete heart block during a general anaesthetic although its onset is a well-recognised complication of sarcoidosis.

Cardiac involvement in sarcoidosis was reported first in 1929,[1] and for some years it was considered to be a rare complication. This view has been modified in the last 20 years as the number of documented cases has increased. Silverman[2] performed autopsies on 84 patients with sarcoid in 1978 and found that 27% had myocardial granulomata. About one third of these were silent and two thirds had presented with conduction defects, dysrhythmias or heart failure. Complete heart block, which is the commonest cardiac presentation, was reported first in 1939.[3] An analysis of 57 patients with complete heart block and sarcoid in 1985[4] showed that the former was the first sign of the disease in 72% of cases. Other signs of cardiac involvement, in order of frequency of presentation, are ventricular extrasystoles or ventricular tachycardia, myocardial disease which causes heart failure, sudden death, first degree heart block or bundle branch block.[5]

The pathological lesions in the heart can be diffuse or focal. Widespread acute granulomata may resolve to produce a diffuse interstitial fibrosis which results in a generalised hypokinesis and heart failure. This type of cardiac sarcoid is indistinguishable clinically from any other cardiomyopathy. More commonly there may be a localised fibrous scar which leads to a focal abnormality of contraction; this may be asymptomatic, but can be demonstrated on echocardiography. The sarcoid lesions are localised most commonly to the basal portion of the ventricular septum and the left ventricular wall.[6] There may be a few, relatively small, lesions in some patients. However, dysrhythmias or conduction defects occur if these happen to involve the conducting system; echocardiography may be normal in such cases.

The patient reported here belongs to this last category. Not only was he asymptomatic before admission, but his exercise tolerance was above average. All his previous outpatient ECGs had been normal. Was the onset of complete heart block entirely coincidental or, on the assumption that a sarcoid granuloma which involved the conducting tissue was already present, but as yet asymptomatic, could a permanent block have been precipitated by the anaesthetic? Dysrhythmias occur frequently during anaesthesia, but usually they are temporary, and disappear after the withdrawal of the anaesthetic drugs. A number of animal studies have shown depression of AV nodal and His-Purkinje conduction times during anaesthesia with halothane or enflurane,[7–9] but there is no suggestion that irreversible changes occur in the conducting tissue. Clinical experience has shown that patients with existing conduction defects are at risk of a progression to complete heart block during anaesthesia, although these animal results cannot necessarily be extrapolated to humans. Atlee *et al.*[9] used specialised His bundle recording techniques to study the effect of enflurane anaesthesia on specialised atrioventricular conduction times in dogs. They showed increases in AV nodal, and in His-Purkinje conduction times, of 17% and 5% respectively. The conduction depression occurred under light anaesthesia, and was not increased with greater anaesthetic depth. The authors suggested that this was an indirect, probably autonomic, effect of anaesthesia. They acknowledged that the magnitude of the effect was small and unlikely to cause AV block in normal patients. However, they suggested that this might not be the case in a patient with previously impaired conduction, or on treatment with beta blockers or calcium channel blockers.

Difficulties with pacemaker management in cardiac sarcoidosis have been described,[10] and we were surprised at the rapidity with which this patient became pacemaker-dependent. A trial reduction to 20 beats/minute produced no intrinsic activity and if the onset of his heart block had occurred while surfing, the patient might not have survived. Indeed, there have been a number of reports of sudden death in association with sarcoid disease.[11,12] Roberts[11] analysed the autopsy results of 89 patients with cardiac sarcoid and found that sudden death had occurred in 60 (67%) patients. In 10 of these, average age 31 years, sudden death was the initial manifestation of cardiac sarcoid; death had occurred in eight during exercise. Thirty-eight of the remaining 50 had documented evidence of complete heart block or a ventricular dysrhythmia, four had atrial dysrhythmias, one had right bundle branch block, and seven had no ECG records. Sudden death may occur in association with either complete heart block or ventricular tachydysrhythmias.

Cardiac involvement was the initial manifestation of the sarcoid in 88% of patients in one report[11], and it has been suggested that the severities of cardiac and noncardiac involvement are related inversely.[12] Fleming[5] comments that several transplant centres have found undiagnosed sarcoid of the heart in occasional cases of 'cardiomyopathy'.

Another cause of dysrhythmias and conduction defects in fit young patients is the condition known as 'athlete's heart'. Bradycardia, cardiac enlargement, first and second degree heart block, right bundle branch block, and ST segment and T wave abnormalities have all been described in athletes who participate in endurance sports.[13] These changes are thought to be related to the physiological adaptation of the heart to regular extreme exercise, which may result in left ventricular hypertrophy and dilatation. These changes may present first during anaesthesia[14,15] or be found unexpectedly on a routine ECG, and may be misinterpreted as an indication of heart disease. 'Athlete's heart' is a benign condition and the heart is thought to function at its best under a load, although differentiation from heart disease is not always easy.[13] There is no progressive abnormality on exercise testing and the ST and T wave changes often become normal. The complete heart block which developed during anaesthesia in this patient was obviously not benign, as it was irreversible and required insertion of a permanent pacemaker.

Conclusion

Complete heart block is a recognised complication of sarcoidosis and, together with ventricular dysrhythmias, may be responsible for the sudden death which sometimes occurs in patients with cardiac involvement. Anaesthesia may have been a precipitating factor in the sudden development of this patient's complete heart block, although a pre-existing lesion in the conducting tissue must have been present. Anaesthetists should be aware not only that conduction defects can occur in the apparently fit patient with sarcoidosis, but also that heart block may be the presenting feature of previously undiagnosed sarcoidosis.

Acknowledgments

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References

1. Bernstein M, Konzlemann FW, Sidlick DM. Boeck's sarcoid: report of a case with visceral involvement. *Archives of Internal Medicine* 1929; **44:** 721–34.
2. Silverman KJ, Hutchins GM, Bulkley BH. Cardiac sarcoid: a clinicopathologic study of 84 unselected patients with systemic sarcoidosis. *Circulation* 1978; **58:** 1204–11.
3. Cotter EF. Boeck's sarcoid; autopsy in a case with visceral lesions. *Archives of Internal Medicine* 1939; **64:** 286–95.
4. Pehrsson SK, Tornling G. Sarcoidosis associated with complete heart block. *Sarcoidosis* 1985; **2:** 135–41.
5. Fleming HA. (Editorial) Sarcoid heart disease. *British Medical Journal* 1986; **292:** 1095–6.
6. Valantine H, McKenna WJ, Nihoyannopoulos P, Mitchell A, Foale RA, Davies MJ, Oakley CM. Sarcoidosis: a pattern of clinical and morphological presentation. *British Heart Journal* 1987; **57:** 256–63.
7. Atlee JL, Rusy BF. Atrioventricular conduction times and atrioventricular nodal conductivity during enflurane anesthesia in dogs. *Anesthesiology* 1977; **47:** 498–503.
8. Ozaki S, Gotoh Y, Nakaya H, Azuma M, Kanno M. Electrophysiologic effects of enflurane and halothane on isolated rabbit hearts in the presence and absence of metabolic acidosis. *Anesthesia and Analgesia* 1985; **64:** 1060–4.
9. Atlee JL, Brownlee SW, Burstrom RE. Conscious-state comparisons of the effects of inhalation anesthetics on specialized atrioventricular conduction times in dogs. *Anesthesiology* 1986; **64:** 703–10.
10. Lie JT, Hunt D, Valentine PA. Sudden death from cardiac sarcoidosis with involvement of the conduction system. *American Journal of the Medical Sciences* 1974; **267:** 123–8.
11. Roberts WC, McAllister HA, Ferrans VJ. Sarcoidosis of the heart. A clinicopathologic study of 35 necropsy patients (group I) and review of 78 previously described necropsy patients (group II). *American Journal of Medicine* 1977; **63:** 86–108.
12. Lemery R, McGoon MD, Edwards WD. Cardiac sarcoidosis: a potentially treatable form of myocarditis. *Mayo Clinic Proceedings* 1985; **60:** 549–54.
13. Tunstall Pedoe D. Sports Injuries. Cardiological problems. *British Journal of Hospital Medicine* 1983; **29:** 213–220.
14. Abdulatif M, Fahkry M, Naguib M, Gyamfi YA, Saeed I. Multiple electrocardiographic anomalies during anaesthesia in an athlete. *Canadian Journal of Anaesthesia* 1987; **34:** 284–7.
15. Bullock RE, Hall RJC. Athletic dysrhythmias. A case report and review of the phenomenon of the 'athlete's heart'. *Anaesthesia* 1985; **40:** 647–50.

Anaesthesia, 1988, Volume 43, pages 581–583

APPARATUS

The Ohmeda Excel anaesthetic machine

C. P. EMMETT, T. H. CLUTTON-BROCK AND P. HUTTON

Summary

The Ohmeda Excel 410 anaesthetic machine is described. A report of its use on 100 patients and impressions of its innovations are given.

Key words

Equipment; anaesthetic machines.

In the recent past Ohmeda manufactured a wide variety of different anaesthetic machines, each of which offered different combinations of facilities and was constructed from machine specific components. The company has now made a policy decision to produce a limited range of machines of constant design features with interchangeable parts and long service intervals. The Excel machines which reflect this philosophy were launched for sale in Britain on 12 March 1987. Their production followed interviews with a large number of anaesthetists internationally. The appearance of the machine resembles the familiar Boyle's machine and the top of the range model, the Excel 410 is shown in Fig. 1.

The Excel has a steel base with large aluminium extrusions as vertical pillars. These pillars incorporate a female dovetail section throughout their height into which can be fitted small clamps, which give potential for the machine to carry more equipment. The effect is very strong and stable. There is a large shelf area at the top which is perforated to allow equipment to be fixed firmly. Double sided castors run easily and may be locked by a bar on the front of the machine which doubles as a footrest. There is a pillar which connects the base to the front of the desk surface and which supports the circle absorber system.

There are two sizes of machine, the 410 which delivers four gases (oxygen and a choice of three of N_2O, air, CO_2, nitrogen or helium) and has three vaporizers, and the 210 a three gas, two vaporizer model which is physically smaller. There is no facility for cyclopropane on either model.

Gas can enter the high pressure blocks on the machine from either a pipeline or a cylinder. The blocks are fitted modularly and are gas specific, with pin indexed entry ports and thread and diameter indexed outlets; they may not be converted for use with another gas. A one-way valve

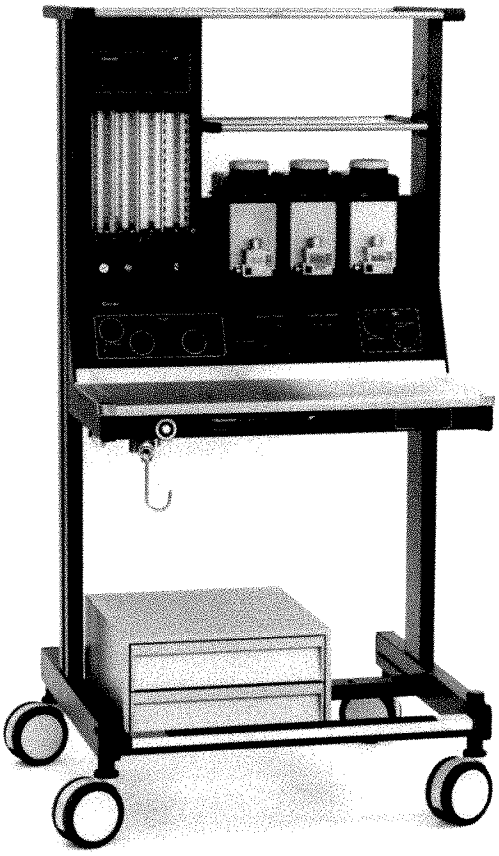

Fig. 1. The Ohmeda Excel 410.

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preferentially allows gas from the pipeline to flow when both cylinder and pipeline are switched on, although this is dependent on cylinder pressure. It also prevents back flow into the pipeline or cylinder from the machine. Each block also incorporates an over-pressure safety valve which blows off at 666 kPa. The pressure gauges seen on the front of the machine are integral with the blocks and are fitted directly into channels milled into the high pressure and pipeline chambers. The pressure reducing valve on the cylinder outlet has a metal diaphragm which is expected to last the life of the machine.

From the gas inlet blocks to the rotameters and from the last vaporizer to the common gas outlet the pipework is entirely enclosed, which means accidental damage from beneath is unlikely.

The internal pipework contains the mechanism of the O_2 safety alarm which operates from a reservoir contained in the desk top space. The reservoir is pressurised when the machine is switched on and the alarm sounds for about 0.5 seconds until the internal pressure has reached 226 kPa. The oxygen failure alarm sounds when the supply pressure decreases below 226 kPa. An inbuilt reservoir supplies the alarm for about 9 seconds if the oxygen failure is complete. The alarm will sound continuously if the oxygen pressure is between zero and 226 kPa until the supply runs out. All other gases are switched off (not vented) except for any residual oxygen flow when the oxygen pressure falls below 226 kPa. As the oxygen supply decreases further, atmospheric air may be entrained by a valve which requires -1 kPa to open. This may be operated by the patient's effort or by active intake into the ventilator bellows if there has not been a simultaneous failure of the air pressure line. The oxygen concentration from entrained air will not be reduced because all hypoxic gases will have been switched off automatically. The oxygen flush remains functional during oxygen failure whilst there is any residual oxygen pressure.

The oxygen Rotameter operates at 133 kPa downstream of a secondary pressure regulator and stabiliser. There will be no change in delivered O_2 percent because of pressure decrease since the O_2 pressure alarm and gas shut off system operates at pressures lower than 226 kPa until the cut off point is passed, when a hypoxic mixture is again prevented.

The N_2O Rotameter also operates downsteam of a secondary regulator and works at the higher pressure of 226 kPa. Back flow following outlet blockage is prevented by the 26.7 kPa relief valve upsteam of the common gas outlet.

The Rotameter block is made up of modular units; each module has a pin indexed top and bottom and only accepts its gas specific Rotameter tube. The flow tubes are 26.6 cm long which improves visual clarity. There are double Rotameters available for O_2 and N_2O designed for low flow anaesthesia. The gas passes serially first through a 1 litre/minute (full scale) tube and then through the second tube which has a normal flow scale.

The oxygen and nitrous oxide control valves are linked to prevent hypoxic mixtures being given (Fig. 2). The minimum percentage of O_2 permitted in the presence of N_2O is 25% with a range of ±4%. This maintains the normal atmospheric concentration of oxygen under the worst conditions.

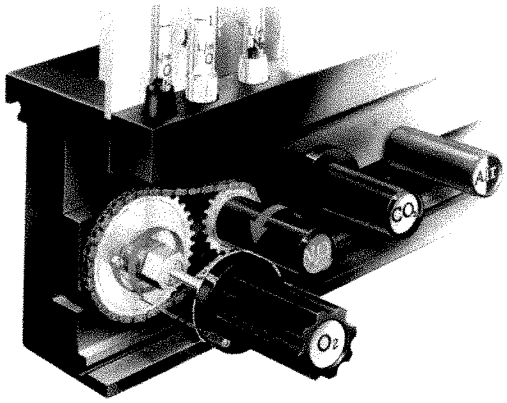

Fig. 2. The oxygen/nitrous oxide valve linkage.

The valves are connected by a chain on gear wheels. They function such that O_2 is independent of N_2O when O_2 is turned on, but the link engages with N_2O at 25% O_2 when O_2 is turned off. Conversely N_2O is linked with O_2 at 25% when N_2O is turned on, but independent of O_2 when N_2O is turned off. Thus any oxygen concentration above 25% may be set and the N_2O is progressively turned off by the linkage as hypoxic mixtures are attempted. In any Rotameter valve there is bound to be some backlash and in order to ensure that the oxygen concentration at low flow is at least 25% there is a basal oxygen flow at all times of between 170 and 250 ml/minute. This is activated by the pneumatic switch (see below) and is always present even when the O_2 Rotameter valve is in the 'off' position. The flow control valves have an end stop when they reach the 'off' position, and prevent forcing of the needle valve into its seating. Wear on the valve seating and looseness in the valve thread in the conventionally designed valve is the common cause of difficulty in turning on. To eliminate any looseness in the threads these valves are spring-loaded. This also gives a more positive setting and minimises any flow fluctuations from lateral or axial pressure applied to the flow control knob. The control knobs are recessed with the oxygen knob proud of the others and the CO_2 valve, when fitted, has a stop which prevents flow greater than 2 litres/minute.

There are either two or three vaporizers fitted by the Selectatec method depending upon the model. There is a mechanical interlock between the vaporizers which prevents the control dial on one vaporizer being turned on whilst another is in use and it continues to work when any one of the three vaporizers is removed.

The common gas outlet is on a Cardiff swivel connected to the fresh gas flow by a flexible pipe so that it may be fitted to the right or left front of the machine desk top as a factory fitted option. All systems in the machine are activated by the pneumatic switch (Fig. 3). The switch is a knob which rotates through 90 degrees from 'off' to 'on' with a positive 'flick over' feel at the half-way point. The basal oxygen flows and the oxygen alarm reservoir fills when it is switched on, which then turns on the other gases. There is a positive alarm sound for 0.5 seconds when it is switched on (see above) but no alarm when it is switched off. This prevents an annoying prolonged alarm sound every time the machine is switched off and is designed to differentiate between oxygen failure and no oxygen because of the machine being switched off. However, it would be in keeping with the rest of the features on this machine if the venting

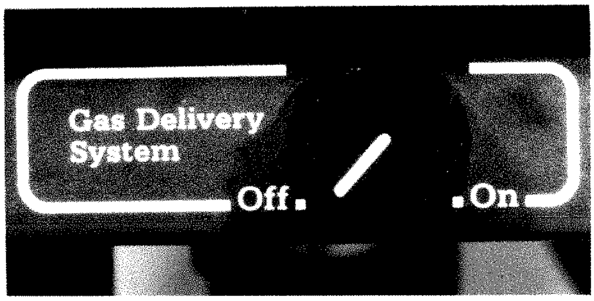

Fig. 3. The pneumatic switch.

gases were routed through a sounding device which would sound for about 0.5 seconds and simply draw attention to the action.

The pneumatic switch also activates any integrated electronic systems on the machine. On the machine tested these were incorporated in a preproduction model of a ventilator/monitor which is still under development and will be marketed as an additional option to the basic machine at a later date.

Results

One hundred patients were anaesthetised using the Excel 410 for a wide variety of cases which ranged from an examination under anaesthetic to liver transplantation. The total anaesthetic time was 146 hours 30 minutes: 55 patients were ventilated and the circle system was used in 67 cases, of which 24 breathed spontaneously. The shortest case was 5 minutes, the longest 8 hours. The machine functioned well and was straightforward in use once its differences from the conventional Boyle's machine were understood.

We feel it needs emphasis that an anaesthetist coming upon the machine for the first time would not necessarily be able to use it. He or she would find an inert piece of equipment that was not activated by normal manoeuvres. Therefore it is not a machine to be left in theatre for an on-call anaesthetist to use for the first time during an emergency. It is essential, in our view, when an Excel is purchased that every anaesthetist in the department should undergo a practical familiarisation procedure, and this should continue for any new staff who have not previously used the machine.

The structure of the machine was good and safely held the large number of monitors and pumps used in the more complex cases. There appeared to be adequate space. We were critical of the dovetail fitted dripstand, which could allow fluids to fall on to electrical equipment below and which we believe should be redesigned or abandoned. The machine moved easily into position and the brake made the unit firm against accidental movement, and protected the pipe linkage to the patient.

The ventilator was used through the circle system on 78% of ventilated patients with low flows using the absorber and with intermediate flows without the absorber; normocapnia was maintained with a minute volume of 100 ml/kg. The twin Rotameter system was particularly good for low flow settings, both for spontaneous and mechanical ventilation: adjustment of a small change in fresh gas was positive with the well-engineered flow control valves.

The gas valves are in the normal place and come easily to hand, and the three vaporizers are widely enough spaced and clear of other parts of the machine for comfortable handling. The oxygen flush button is clearly placed near the common gas outlet and operated without difficulty.

The pneumatic switch was used between cases to shut the machine down because the integrated ventilator/respiratory monitor we used would alarm if there were no ventilation (artificial or spontaneous) registered. The advantage of switching off is that the gas flows and vapour concentration required for the next patient may be set before it is switched off, which enables one switch movement to deliver accurately the right gas mixture. This reduces the time of apnoea or breathing room air between the anaesthetic room and the theatre and is particularly useful in short, fast turnover lists.

The users of the machine were critical of the lack of signal when the pneumatic switch was turned off. Switching 'on' causes an audible alarm noise whereas switching 'off', which leaves the Excel inert, causes only the sound of the internal pipework depressurising.

The concept of integrating the ventilator and respiratory parameters ($F\text{I}O_2$, tidal volume, respiratory rate, and breathing system pressure) with the gas systems on an anaesthetic machine is a new approach, and works well. The electronic part which is being further developed at present will be reviewed when the production model is tested clinically.

Acknowledgment

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APPARATUS

Electrical distribution boards in the operating theatre

M. NIEMAN, A. SHAW AND R. RAILTON

Summary

The safe use of electrical distribution boards in operating theatres is described, with particular reference to British Standard 5724. Recommendations as to a practical working policy are made.

Key words

Equipment; electrical distribution boards.

The increased use of electrically operated equipment such as patient monitors and sophisticated lung ventilators has meant that more mains sockets are required in the operating theatre. This need has usually been met by multi-outlet distribution boards powered from a single 13-amp socket. These boards can either be located on the floor of the operating theatre, mounted on a special stand, or attached to the anaesthetic machine: at least one manufacturer provides anaesthetic machines fitted with such boards (Fig. 1).

The use of distribution boards needs to be carefully considered since they may present a hazard in the operating theatre. There are various risks involved and it is necessary to look at these if a practical policy for safe operation of the equipment is to be developed.

Risks arising from distribution boards

Static and explosion risk. In 1971 the Association of Anaesthetists specified a zone of risk in which special precautions were necessary to guard against spark hazards caused by build up of static or from electrically operated equipment.[1] British Standard 5724 Part 1 redefined the zones of risk and this supersedes previous advice.[2] Distribution boards placed on the floor can easily find their way under the operating table. This area is defined in BS 5724 as a 'zone of risk' when flammable skin preparations are used. The Standard defines another zone of risk as the space within 25 cm of any part of an enclosed medical gas system from which a leak might occur. This zone also includes part of the gas scavenging system as defined in BS 6834.[3] Boards mounted on special stands could be moved inadvertently into either of these zones of risk. Plug disconnexion while current is flowing could create a spark, since the boards are not spark-proof.

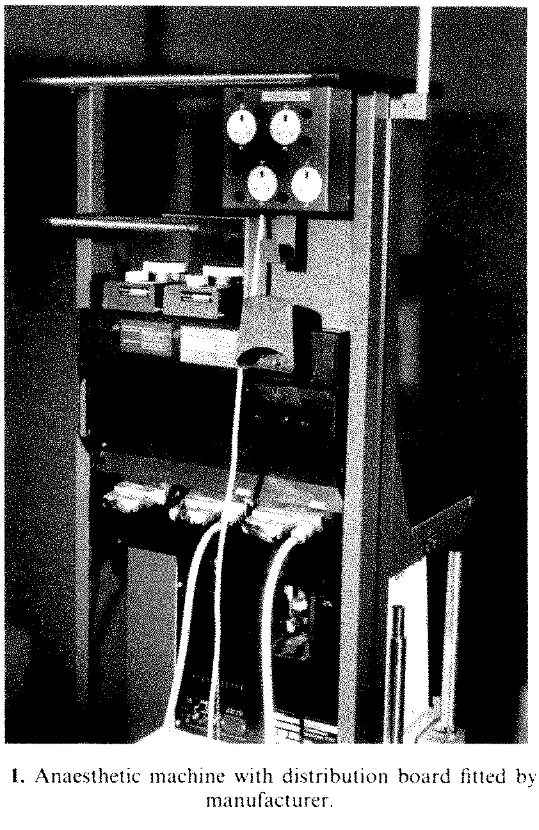

Fig. 1. Anaesthetic machine with distribution board fitted by the manufacturer.

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Loss of supply. Most pieces of equipment have either one or more supply fuses or circuit breakers to protect against the equipment drawing excessive current. This is in addition to the fuse in the mains plug and each of these fuses must be of the correct rating. The distribution board normally has a separate 13A fuse as well as its own plug fuse, but obviously the total current load from the equipment connected to the distribution board should be kept below 13A. A serious fault on one piece of equipment, even with correct fusing, might blow the distribution board fuse, and result in power loss to all pieces of equipment connected to the board. The use of a manually resettable miniature circuit breaker instead of a fuse in the distribution board could be an improvement, where technical staff construct their own distribution board assemblies.

It is important that nothing should imperil the common supply; for example fitting an RCCB (Residual Current Circuit Breaker, previously called an Earth Leakage Circuit Breaker) in the supply to the distribution board in an attempt to improve safety would increase the chance of supply loss to all pieces of equipment. Surges on the main supply, in addition to a genuine fault on any piece of equipment, can cause the RCCB to operate. Use of RCCBs on each piece of equipment may alleviate at least part of this problem since a genuine fault would cause interruption of the mains supply only to the specific piece of equipment involved. However some or all of the RCCBs might trip if there was an externally generated surge on the mains. Other disadvantages include the increased bulk and doubling of the number of connexions.

A distribution board with good cable grips is required to prevent disconnexion of the supply, if the lead is inadvertently pulled. The board, cable and plug must be checked regularly for tightness of electrical connexions, cable damage and appropriate fusing. Spillage of liquid could cause a short circuit and loss of power, if the distribution board is lying on the ground. Splash-proof boards could be used (if available) but probably the safest place for the board is above the back-bar on the anaesthetic machine or near the top of a monitoring trolley, with the face of the sockets vertical. The board should be at least 25 cm above the bar if there is a possibility that a flammable anaesthetic agent could be employed without the need of tools to modify the anaesthetic machines. This essentially means that the 25-cm rule should be applied to anaesthetic machines fitted with a cyclopropane yoke, or an ether vaporizer, even if these are not normally used. It also applies to anaesthetic machines fitted with a Selectatec back-bar because of the possibility of fitting an Ethertec vaporizer. An additional advantage is that it is virtually impossible for the board to be moved into the zone of risk under the operating table if it is fitted in this position.

Electric shock. The use of a distribution board means that the earth connexion to all equipment on the board comes through a single cable and plug. Equipment defined in BS 5724 as class I, requires an earthed case to protect the user against electric shock. In normal use a small amount of 'leakage current' flows down the earth wire and an allowable limit of 0.5 mA is specified in BS 5724. This results in maximum enclosure leakage current of 0.5 mA, because if the earth connexion to equipment is broken, then 0.5 mA of current is the maximum that can flow to earth through someone touching the equipment. Leakage currents are amongst items checked by technical staff with special equipment during normal safety checks or preventive maintenance procedures. The sum of the earth leakage currents for all the equipment connected to the board should not exceed 0.5 mA to keep strictly within the limits of BS 5724. The maximum current that can flow to earth through someone touching any piece of class I equipment connected to the board is still 0.5 mA if, for example, there is no connexion to earth on the distribution board plug. This current might flow through the patient, if any of these pieces of equipment had an earthed part connected to the patient. An external connexion with 0.5 mA of current flowing presents little hazard normally but in some applications there might be more serious consequences. Whether or not a distribution board is used, if a procedure such as catheterisation is carried out where type CF equipment (i.e. cleared for internal cardiac use) is essential then all equipment connected to the patient should be of type CF.

The lack of earth connexion does not affect the safety of class II or double insulated equipment, because the insulation layer is sufficient to provide protection against electric shock.

The leakage currents and total current flowing need to be restricted to keep within the limits of BS 5724. In practice, use of different combinations of medical equipment on a distribution board is unlikely to present a significant hazard. Leakage currents are usually well below the required level (but should of course be measured regularly) and supply currents are also low with most modern equipment. Items which do require a large current or have leakage current close to the limit should be labelled as not to be used with a distribution board.

General purpose equipment, such as computers, may not be manufactured to the same safety standards as medical electrical equipment; in particular it may have high leakage currents and be less reliable, and should therefore have its own mains supply. Equipment of this nature should be clearly labelled, so that it is not plugged into the same distribution board as medical equipment. An alternative is to power general purpose equipment through an isolating transformer.

Distribution boards can either be plastic or rubber cased or have an earthed metal case. Some care is required if it is decided to fasten distribution boards to the anaesthetic machine or to a monitoring trolley, and the work should be carried out by a qualified technician or engineer. Some distribution boards with a plastic or rubber enclosure have mounting holes close to bare internal bus-bar connectors. Screws to mount these boards directly on to a metal trolley should be made of an electrical insulating material to maintain double insulated standards and prevent hazards. A metal screw which becomes loose could either short across conductors or possibly form a path from a live conductor to the metal trolley. Boards with an earthed enclosure should be mounted by an intermediate insulating panel. In our opinion earthing the anaesthetic machine or trolley is not the right course of action, since this could bypass the high electrical resistance of theatre staff footwear and the patient's mattress.

Conclusion

Equipment should be supplied from permanently installed mains sockets whenever possible. The use of distribution

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SPECIAL ARTICLE

Clinical relevance of the B_{12}/N_2O interaction

A report of a seminar

J. F. NUNN

Summary

The interaction of nitrous oxide and vitamin B_{12} and its implications are not the exclusive territory of any one discipline. The initial discovery was by a chemist but it is of obvious relevance to anaesthetists and intensivists; some complications are neurological others haematological. The interaction provides an extremely important research tool as the first easily available B_{12}-deficient animal model. Finally there are implications for exposure to contaminated atmospheres in hospitals and in industry.

Key words

Anaesthetics, gases; nitrous oxide.

It is remarkable that B_{12} chemists, and particularly those who first discovered the interaction with nitrous oxide, have until now had only minimal contact with clinicians. The first publication of the discovery of the interaction[1] was followed by an interval of 10 years before clinicians became generally aware that a problem existed.

As a first step towards establishing a dialogue between basic scientists and clinicians in the field, an interdisciplinary Bedford Square Seminar was held on 26 January 1988. Invited speakers and discussants included many of the leading chemists, haematologists, neurologists and anaesthetists in this country who had worked in the field during the last 20 years.

The seminar opened with a review by Professor B. Golding (*Department of Organic Chemistry, University of Newcastle-upon-Tyne*) of the basic biochemistry of B_{12} and its role in man as a cofactor for the enzymes, methionine synthase and methylmalonyl CoA mutase. The reactivity of the cobalt atom at the centre of the corrinoid ring (which closely resembles the tetrapyrrole ring of haemoglobin) was considered in detail, with particular reference to the potential nature of its reaction with nitrous oxide and subsequent change in valency. The possibility was also considered of the formation of a cobalt-carbon bond with alkyl halide anaesthetics. Earlier negative studies with halothane did not exclude this possibility because of the lability (for example, photosensitivity) of the bond.

Professor J.M. Pratt (*Department of Chemistry, University of Surrey*) provided the background of his discovery of the *in vitro* nonenzymic interaction of nitrous oxide and B_{12}. It started with experiments of his own, undertaken 'out of sheer curiosity' in 1963, and completed by two project students; it was published under the authorship of Banks, Henderson and Pratt as a preliminary note in 1967[2] and a full paper in 1968[1]. Both escaped the notice of the medical profession for several years. However, a brief note of the interaction appears in Professor Pratt's textbook of vitamin B_{12} published in 1972.[3] Professor Pratt concluded with the challenging hypothesis that B_{12} had an earlier role in evolution for the metabolism of methane before oxygen appeared in the earth's atmosphere, and was used for methyl transfer reactions which still occur in certain bacteria.

In discussion, Dr J. Amess (*Department of Haematology, St Bartholomew's Hospital*) explained that during 1974–76 he observed intensive care unit patients who developed megaloblastic bone marrow change secondary to prolonged ventilation with nitrous oxide. This had been previously reported by Lassen[4] during 1956 but its pathogenesis had remained unexplained. In association with Dr J. Burman, it was shown that the results of the deoxyuridine suppression tests, on the bone marrow from these patients, were identical to those found in vitamin B_{12} deficiency, but the patients' serum B_{12} concentrations were normal. These findings suggested vitamin B_{12} inactivation by nitrous oxide and the reason for this was found in Professor Pratt's textbook. Dr Amess' paper at the Fourth Meeting of the European and African Division of the International Society of Haematology in Istanbul,[5] followed by his classic paper in *Lancet*[6] of August 1978, was the forerunner of most of the work which was discussed in the remainder of the Symposium.

Dr I. Chanarin (*Head of Section of Haematology, Clinical Research Centre*) described the direct observations of the

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inhibition by nitrous oxide of methionine synthase activity in the rat[7] in 1978 and contrasted this with the lack of any direct effect on methylmalonyl CoA mutase. He then reviewed the extensive consequences on folate and methionine metabolism, stressing the effect of nitrous oxide on entry of folates into the cell and the production of folate polyglutamates (the active form of folates).[8] The increased plasma folate seen after B_{12} inactivation resulted in extensive urinary loss of folates. It was still not entirely clear how nitrous oxide produced this important effect. Recent work from his department has shown that methionine infusions in the nitrous oxide-treated rat resulted in extensive conversion of methyltetrahydrofolate to tetrahydrofolate, by a mechanism which was still not clear.

Mrs B.D. Royston (*Division of Anaesthesia, Clinical Research Centre*) reported studies of the time-course of inhibition of hepatic methionine synthase by nitrous oxide.[9] The half-time in man (46 minutes) was far longer than in the rat, the usual laboratory model, which had a half-time as short as 5.6 minutes. There was inevitable difficulty in prediction of effect in operations of medium duration.

Professor D.G. Weir (*Department of Clinical Medicine, University of Dublin*) reviewed the production of a demyelinating condition, resembling subacute combined degeneration of the cord, which was reported by Layzer[10] in patients with chronic exposure to high concentrations of nitrous oxide, usually as a result of the recreational use of the gas. Evidence was presented to show that N_2O given over a period of 35–55 days caused severe neurological abnormalities and death in monkeys. The clinical and neurological histology of the lesions were similar to those described for subacute combined degeneration (SACD).[11] It was subsequently shown in four experiments with pairs of monkeys in N_2O that if one of the pair was given excess methionine the neurological lesion was prevented.[12] These results suggested that the cause of SACD in vitamin B_{12} deficiency is because of lack of the methylation reactions derived from S-adenosyl methionine (SAM), which in turn is due to methionine deficiency caused by interruption of its endogenous synthesis which is known to be inhibited by N_2O. It was postulated how exogenous methionine could prevent, and excessive folate exacerbate, the neurological lesions.[13] Subsequent studies with the fruit bat in N_2O confirm these findings, although as yet there is no confirmation that brain SAM levels are depressed in this model.[14] However, SAM levels are reduced in a patient with methylene reductase deficiency who has neurological changes suggestive of SACD (Hyland *et al.* in press), which suggests that this is the mechanism of the neurological disease in man.

Dr R.J. Amos (*Department of Haematology, St Bartholomew's Hospital*) reviewed the sequence of studies[15–19] carried out at St Bartholomew's Hospital on the haematological consequences of exposure to nitrous oxide in the seriously ill. Early experience with prolonged use of Entonox reproduced the pancytopenia and megaloblastic marrow change first reported during the treatment of patients with tetanus.[4] Once aware of Professor Pratt's work they used the deoxyuridine suppression test to demonstrate that these changes were caused by inactivation of vitamin B_{12} *in vivo*. Further studies demonstrated that megaloblastic bone marrow change and an abnormal deoxyuridine suppression test might develop after as little as 2 hours' surgical anaesthesia with nitrous oxide in patients subsequently admitted to Intensive Care.[16] They found an 87% mortality in patients who developed megaloblastic change after nitrous oxide but considered that severity of illness was a causal factor, rather than a consequence, of the megaloblastic change. There followed a discussion on the difficulty of resolving the problem of the clinical consequences of nitrous oxide administration to the seriously ill patient.

In discussion, Professor Weir stressed the problem of folate deficiency which occurred in the acutely ill patient who had received nitrous oxide.[20] This came about partly because of interference with polyglutamation of folates and entry into cells, and partly because of deficiency in exogenous sources of folates in these patients. He also stressed that folate was not transferred from one organ to another with the ease characterised by iron, for example. These factors indicated that steps should be taken to ensure an adequate supply of parenteral folate and that the period under nitrous oxide anaesthesia should be limited.

The difficult problem of fetotoxicity of nitrous oxide was reviewed by Dr M.J. Halsey (*Division of Anaesthesia, Clinical Research Centre*). There could be no doubt of the mild teratogenic effects of nitrous oxide in certain species of laboratory animal exposed during organogenesis.[21] However, the clinical significance of these findings was complicated by many factors, which included species difference, statistical difficulties, the duration and timing of exposure in relation to organogenesis, the end-points used in the various animal studies and the great difficulty of controlling physiological factors in the dams. He drew attention to the existence of 10 epidemiological studies and case reports all of which were entirely negative. In discussion, Dr R.I. Mazze (*Department of Anesthesiology, Stanford University*) drew attention to his own studies[22,23] in which the volatile anaesthetics, halothane and isoflurane, but not folinic acid, prevented fetal wastage and reversed visceral teratogenic effects of nitrous oxide in the rat. This contrasted with the partial reversal seen with folinic acid in skeletal abnormalities which had been previously reported.[24] Dr Mazze suggested that since the volatile anesthetics did not prevent nitrous oxide-induced inhibition of methionine synthase activity, other mechanisms may be involved in nitrous oxide teratogenicity.

The final session considered atmospheric pollution with nitrous oxide. Dr J.F. Nunn (*Division of Anaesthesia, Clinical Research Centre*) reported that the latest figures from the Medical Research Council study of women doctors who worked in operating theatres indicated no significant effect on either abortion or fetal malformations. Theatre contamination tended to be less than 400 parts per million (ppm), even without scavenging, and this was less than the minimal concentration which caused a measurable effect on hepatic methionine synthase activity in the chronically exposed rat.[25] Dr P.V. Cole (*Department of Anaesthesia, St Bartholomew's Hospital*) reviewed the problem of contamination when dental surgeons used nitrous oxide for relative analgesia.[26,27] Nitrous oxide concentrations inhaled by the dentist could then be above 5000 ppm (the ED_{50} for methionine synthase inactivation for chronic exposure in rats). Two dentists had been found to have mild megaloblastic changes in the erythroid series of their bone marrow and three had abnormal values for the deoxyuridine suppression test.[28] Hypersegmented neutrophils were also found in the peripheral blood.

The meeting provided a valuable occasion for exchange of information between different disciplines and many workers received new insight into the problems with which they were confronted. It was abundantly clear that there was a major gap in knowledge of the clinical relevance of the metabolic consequences of nitrous oxide administration in the seriously ill patient. There was need for controlled randomised, double-blind studies in seriously ill patients who either did or did not receive nitrous oxide in the course of an anaesthetic. It was clear that such studies would present the greatest difficulties in execution.

References

1. Banks RGS, Henderson RJ, Pratt JM. Reactions of gases in solution. Part III. Reactions of nitrous oxide with transition metal complexes. *Journal of the Chemical Society* (A) 1968; **12:** 2886–9.
2. Banks RGS, Henderson RJ, Pratt JM. Reactions of nitrous oxide and some transition metal complexes. *Chemical Communications* 1967; 367.
3. Pratt JM. *Inorganic chemistry of vitamin B12.* London: Academic Press, 1972.
4. Lassen HCA, Henriksen E, Neukirch F, Kristensen HS. Treatment of tetanus. Severe bone-marrow depression after prolonged nitrous-oxide anaesthesia. *Lancet* 1956; **1:** 527–30.
5. Amess JAL, Burman JF, Greany M, Nancekievill DG. The effect of nitrous oxide on haematopoiesis. *International Society of Haematology, Istanbul* 1977, Abstract 614.
6. Amess JAL, Burman JF, Rees GM, Nancekievill DG, Mollin DL. Megaloblastic haemopoiesis in patients receiving nitrous oxide. *Lancet* 1978; **2:** 339–42.
7. Deacon R, Lumb M, Perry J, Chanarin I, Minty B, Halsey MJ, Nunn JF. Selective inactivation of vitamin B_{12} in rats by nitrous oxide. *Lancet* 1978; **2:** 1023–4.
8. Chanarin I, Deacon R, Lumb M, Muir M, Perry J. Cobalamin-folate interrelations: a critical review. *Blood* 1985; **66:** 479–89.
9. Royston BD, Nunn JF, Weinbren HK, Royston D, Cormack RS. Rate of inactivation of human and rodent hepatic methionine synthetase by nitrous oxide. *Anesthesiology* 1988; **68:** 213–6).
10. Layzer RB. Myeloneuropathy after prolonged exposure to nitrous oxide. *Lancet* 1978; **2:** 1227–30.
11. Dinn JJ, McCann S, Wilson P, Reed B, Weir DG, Scott J. Animal model for subacute combined degeneration. *Lancet* 1978; **2:** 1154.
12. Scott JM, Dinn JJ, Wilson P, Weir DG. The pathogenesis of subacute combined degeneration: a result of methyl group deficiency. *Lancet* 1981; **2:** 334–7.
13. Scott JM, Weir DG. The methyl folate trap. *Lancet* 1981; **2:** 337–40.
14. Metz J, Van Der Westhuysen J. The fruit bat as an experimental model of the neuropathy of cobalamin deficiency. *Comparative Biochemical Physiology* 1987; (in press).
15. Amess JAL, Burman JF, Rees GM, Nancekievill DG, Mollin DL. Megaloblastic haemopoiesis in patients receiving nitrous oxide. *Lancet* 1978; **2:** 339–42.
16. Amos RJ, Amess JAL, Hinds CJ, Mollin DL. Incidence and pathogenesis of acute megaloblastic bone-marrow change in patients receiving intensive care. *Lancet* 1982; **2:** 835–9.
17. Amos RJ, Amess JAL, Nancekievill DG, Rees GM. Prevention of nitrous oxide-induced megaloblastic changes in bone marrow using folinic acid. *British Journal of Anaesthesia* 1984; **56:** 103–7.
18. Amos RJ. Megaloblastosis in patients receiving intensive care. *MD Thesis, University of Cambridge* 1985.
19. Amos RJ, Amess JAL, Hinds CJ, Mollin DL. Investigations into the effect of nitrous oxide anaesthesia on folate metabolism in patients receiving intensive care. *Chemioterapia* 1986; **4:** 393–9.
20. Weir DG. Folate deficiency in the acutely ill patient. *Clinical Nutrition News* 1984; **2:** 1–3.
21. Lane GA, Nahrwold ML, Tait AR, Taylor-Busch M, Cohen PJ, Beaudoin AR. Anesthetics as teratogens: nitrous oxide is fetotoxic, xenon is not. *Science* 1980; **210:** 899–901.
22. Fujinaga, M, Baden JM, Yhap EO, Mazze RI. Halothane and isoflurane prevent the teratogenic effects of nitrous oxide in rats, folinic acid does not. *Anesthesiology* 1987; **67:** A456.
23. Mazze RI, Fujinaga M, Baden JM. Halothane prevents nitrous oxide teratogenicity in Sprague-Dawley rats, folinic acid does not. *Teratology*; (in press).
24. Keeling PA, Rocke DA, Nunn JF, Monk SJ, Lumb MJ, Halsey MJ. Folinic acid protection against nitrous oxide teratogenicity in the rat. *British Journal of Anaesthesia* 1986; **58:** 528–34.
25. Sharer NM, Nunn JF, Royston JP, Chanarin I. Effects of chronic exposure to nitrous oxide on methionine synthase activity. *British Journal of Anaesthesia* 1983; **55:** 693–701.
26. Hillman KM, Saloojee Y, Brett II, Cole PV. Nitrous oxide concentrations in the dental surgery. Atmospheric and blood concentration of personnel. *Anaesthesia* 1981; **36:** 257–62.
27. Larga N. *Relative analgesia in dental practice.* Philadelphia: W.B. Saunders, 1968.
28. Sweeney B, Bingham RM, Amos RJ, Petty AC, Cole PV. Toxicity of bone marrow in dentists exposed to nitrous oxide. *British Medical Journal* 1985; **291:** 567–9.

Other relevant references for further reading

Davenport HT, Halsey MJ, Wardley-Smith B, Bateman PE. Occupational exposure to anaesthetics in 20 hospitals. *Anaesthesia* 1980; **35:** 354–9.

Dixon RM, Golding BT, Mwesigye-Kibende S, Ramakrishna RDN. Concerning the intermediacy of organic radicals in vitamin B12-dependent enzymic reactions. *Philosophical Transactions of the Royal Society of London* 1985; **311:** 531–44.

Dolphin D, ed. *B12 vol. 1 (Chemistry) and vol. 2 (Biochemistry and Medicine).* New York: Wiley Interscience, 1982.

Fujinaga M, Baden JM, Yhap EO, Mazze RI. Reproductive and teratogenic effects of nitrous oxide, isoflurane, and their combination in Sprague-Dawley rats. *Anesthesiology* 1987; **67:** 960–4.

Golding BT. Vitamin B12. In: Barton D, Ollis WD, eds. *Comprehensive organic chemistry,* Vol. 5. Oxford: Pergamon, 1979: 550–584.

Golding BT, Rao DNR. In: Page MI, Williams A, eds. *Enzyme mechanisms.* London: Royal Society of Chemistry, 1987: chapter 20.

Halsey MJ. Studying toxicity of inhaled general anaesthetics. *British Journal of Anaesthesia* 1981; **53:** 57S–62S.

Koblin DD, Waskell L, Watson JE, Stokstad ELR, Eger EI. Nitrous oxide inactivates methionine synthetase in human liver. *Anaesthesia and Analgesia* 1982; **61:** 75–8.

Nunn JF, Sharer N, Royston D, Watts RWE, Purkiss P, Worth HG. Serum methionine and hepatic enzyme activity in anaesthetists exposed to nitrous oxide. *British Journal of Anaesthesia* 1982; **54:** 593–7.

Nunn JF. Clinical aspects of the interaction between nitrous oxide and vitamin B_{12}. *British Journal of Anaesthesia* 1987; **59:** 3–13.

Pratt JM, Aron J, Chemaly SM, Marques HM. Methyl transfer reactions of cobalt corrinoid (B12) complexes. In: Gray PJ, Glockling F, eds. *Biological alkylation of heavy elements* 1988: 46–61.

Schneider Z, Stroinski A. *Comprehensive B_{12}.* Berlin: Walter de Gruyter, 1987.

Vessey MP, Nunn JF. Occupational hazards of anaesthesia. *British Medical Journal* 1980: **281:** 696–8.

Weir DG, McGing P, Scott JM. Folate metabolism, the enterohepatic circulation and alcohol. *Biochemical Pharmacology* 1985; **34:** 1–7.

Anaesthesia, 1988, Volume 43, pages 590–591

Forum

Postoperative sore throat related to the use of a Guedel airway

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Summary

Eighty-eight patients in ASA classes 1 or 2 and aged between 18–65 years, who were to undergo anaesthesia, were allocated randomly to a group with or without an airway. Methohexitone, nitrous oxide, alfentanil and enflurane were used, with the patients breathing spontaneously. This study showed that there was no significant difference between the two groups in the incidence of sore throat, or any other related symptom, and concludes that the use of an oropharyngeal airway does not increase morbidity among nonintubated patients.

Key words

Apparatus; Guedel airway.
Complications; sore throat.

The incidence of sore throat after general anaesthesia has been said to be between 2 and 70%.[1–5] Previous studies have concentrated on the use of a tracheal tube and cuff design.[6,7] The concurrent use of an airway has been said to cause a sore throat.[8] The aim of this study is to determine the effect of an oropharyngeal (Guedel) airway in place during general anaesthesia, in the unintubated patient.

Method

Patients in ASA classes 1 or 2, aged between 18–65 years, who presented for elective or minor surgery were studied, after ethical approval and patient consent had been obtained. They were allocated randomly to groups with or without an airway. Those with existing upper airway pathology, a known difficult airway, fragile dental work, or who had a nasogastric tube passed were excluded. Patients were also excluded if they had suction to the oropharynx, laryngoscopy or an airway inserted after the operation. Eighty-eight patients were included in the study.

Premedication, if necessary, was with oral temazepam one hour before anaesthesia. Anaesthesia was induced with a sleep dose of methohexitone and maintained with nitrous oxide and oxygen (70/30%), enflurane and alfentanil in incremental doses as required (2.5 μg/kg). A 'Leymed' Guedel airway (Type BS 2927) was used in the airway group. The patients were placed in the left lateral position and 35% oxygen was administered with a face mask at the end of anaesthesia.

Patients were interviewed on the first day after the operation by the anaesthetist who had not administered the anaesthetic and was unaware to which group the subjects had been allocated. Each patient was asked about postoperative discomfort and pain that required the use of an opiate analgesic or a nonsteroidal anti-inflammatory agent. Direct questions about dry or sore throats were kept to the end of the interview. Statistical analyses were by Chi-squared and Fischer's Exact tests for the results, and Student's *t*-test for the comparison of the two groups.

Results

Forty-eight of the patients were in the group with an airway, and 40 in the group without. Three patients in the group with, and one in the group without an airway, developed a sore throat (see Table 1). There was no statistical difference in the incidence of sore throat in either group (Chi-squared, 0.71; Fisher's exact, one tailed p = 0.38).

Table 1. The incidence of sore throat.

	Sore throat	No sore throat
Airway	3	45
No airway	1	39

Table 2. The incidence of any throat complaint.

	Throat complaint	No throat complaint
Airway	13	35
No airway	5	35

Complaints of overall throat discomfort were present in 13 of the airway, and five of the no-airway group (see Table 2). Again there was no statistical difference between the two groups (Chi-squared, 2.03; Fisher's exact, one tailed p = 0.74). Furthermore, the statistical probabilities are so low that it is unlikely that a larger series would reveal a significant difference.

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Discussion

We have specifically studied the influence of an oropharyngeal airway, in place during an anaesthetic, on the incidence of sore throats. Our protocol excluded probable causes such as laryngoscopy, intubation, pharyngeal suction and the passage of a nasogastric tube. The anaesthetic technique did not use humidified gases, and we cannot exclude this as a cause of a throat complaint, but this factor was common to both groups.

None of our patients spontaneously complained of a sore throat, nor did those who had a complaint say that it was severe. Our incidence of sore throat was 4.5%. This is low compared to most reports[2–5] but similar to the findings of Hartsell.[1] Two percent in his series of 100 unintubated patients complained of a sore throat, but there is no comment in his paper on the use of an airway. His study was based on voluntary reports without direct questions. Our overall incidence of all throat complaints was 20%. There was no significant difference between the two groups, even among these patients.

We conclude that the use of an oropharyngeal airway does not cause a sore throat.

Acknowledgments

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References

1. Hartsell CJE, Stephen CR. Incidence of sore throat following endotracheal intubation. *Canadian Anaesthetists' Society Journal* 1964; **11:** 307–12.
2. Wylie WD. Hazards of intubation. *Anaesthesia* 1950; **5:** 143–8.
3. Wolfson B. Minor laryngeal sequelae of endotracheal intubation. *British Journal of Anaesthesia* 1958; **30:** 326–32.
4. Conway CM, Miller JS, Sugden FLH. Sore throat after anaesthesia. *British Journal of Anaesthesia* 1960; **32:** 219–23.
5. Brindle GF, Soliman MG. Anaesthetic complications in surgical out-patients. *Canadian Anaesthetists' Society Journal* 1975; **22:** 613–9.
6. Loeser EA, Orr DL, Bennett GN, Stanley TH. Endotracheal tube cuff design and postoperative sore throat. *Anesthesiology* 1976; **45:** 684–7.
7. Stenqvist O, Nilsson K. Postoperative sore throat related to tracheal tube cuff design. *Canadian Anaesthetists' Society Journal* 1982; **29:** 384–6.
8. Cronin N, Redfern PA, Utting JE. Psychometry and postoperative complaints in surgical patients. *British Journal of Anaesthesia* 1973; **45:** 879–86.

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Edrophonium–hyoscine butylbromide mixture for reversal of neuromuscular blockade: heart rate changes in infants and children

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Summary

The effectiveness of hyoscine butylbromide in the prevention of edrophonium-induced bradycardia was assessed in 50 infants and children. A mixture of edrophonium (1.0 mg/kg) and either atropine (0.01 mg/kg) or hyoscine butylbromide (0.4 mg/kg) was administered to reverse the effects of tubocurarine. An initial bradycardia followed the injection of the edrophonium-atropine mixture. In contrast there was no initial decrease in heart rate after the administration of the edrophonium-hyoscine butylbromide mixture. Hyoscine butylbromide can be used with advantage as a substitute for atropine in edrophonium reversal in infants and children.

Key words

Antagonists, neuromuscular relaxants; edrophonium.
Parasympathetic nervous system; atropine, hyoscine butylbromide.

Edrophonium has been suggested as an alternative to neostigmine for reversal of residual non-depolarising neuromuscular blockade in infants and children because of its rapid onset of action and smaller anticholinergic requirement.[1,2] Bradycardia occurs after administration of an edrophonium–atropine mixture in infants and children because the onset of action of edrophonium is more rapid than that of atropine.[2] Hyoscine butylbromide, a quaternary derivative of hyoscine, is an anticholinergic with a very rapid onset of action,[3] and if administered with edrophonium, might prevent an initial bradycardia. In this study, we have evaluated the heart rate changes after the administration of an edrophonium–hyoscine butylbromide mixture to infants and children.

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Method

The study was approved by the institutional ethics committee. Parents' informed consent was obtained for 50 paediatric patients scheduled for an elective inguinal herniotomy under general anaesthesia. All patients were ASA 1 or 2 and without significant cardiovascular disorders. They were unpremedicated. Anaesthesia was induced by inhalation of a mixture of oxygen, nitrous oxide and halothane. After administration of hyoscine butylbromide 0.4 mg/kg, suxamethonium 2 mg/kg was given to facilitate tracheal intubation. Our normal practice is to administer atropine immediately before suxamethonium in order to reduce the risk of bradycardia. Hyoscine butylbromide was used in this study because its duration of action is much shorter than that of atropine, and would therefore be less likely to affect the heart rate at the end of the procedure. Anaesthesia was maintained with nitrous oxide 66% in oxygen and pentazocine (0.2–0.4 mg/kg); tubocurarine was administered to achieve neuromuscular blockade. All patients received edrophonium 1 mg/kg mixed with either atropine 0.01 mg/kg (*n* = 25) or hyoscine butylbromide 0.4 mg/kg (*n* = 25) at the end of surgery. The mixture was administered intravenously over a period of 30 seconds. Nitrous oxide administration was continued and patient stimulation avoided during reversal and until the study was completed. The electrocardiograph was recorded during, and for 5 minutes after, administration of either mixture. The results (except for sex differences) were analysed by Student's paired or unpaired *t*-tests. Sex differences between the groups were analysed by the Chi-squared test. Probability values less than 0.05 were considered to be significant.

Results

The two groups of patients did not differ in regard to age, weight, and sex (Table 1). The heart rate decreased at first, then returned to the initial rate and remained stable for the remainder of the observation period after administration of the edrophonium–atropine (E–A) mixture. In contrast, there was no initial decrease in heart rate, after administration of edrophonium–hyoscine butylbromide (E–H) mixture. Heart rate increased, and remained elevated from 30 seconds after the start of administration until the end of the observation period (Fig. 1). Fluctuation of the heart rate (highest–lowest) was greater in patients who received E–A mixture (Table 2).

Table 1. Demographic data. Values expressed as mean (SD).

	Age, months	Weight, kg	Sex, m:f
E–A group (*n* = 25)	7.0 (5.8)	7.3 (2.3)	15:10
E–H group (*n* = 25)	6.5 (5.8)	7.2 (2.5)	16:9

E–A, edrophonium–atropine; E–H, edrophonium–hyoscine butylbromide.

Table 2. Heart rate changes beats/minute. Values expressed as mean (SD).

	Highest heart rate	Lowest heart rate	△* heart rate
E–A Group	182 (16)	129 (24)	54 (21)
E–H Group	187 (13)	153 (17)	34 (15)
p	> 0.05	< 0.01	< 0.01

*△ heart rate = highest minus lowest heart rates.
E–A, edrophonium–atropine; E–H, edrophonium–hyoscine butylbromide.

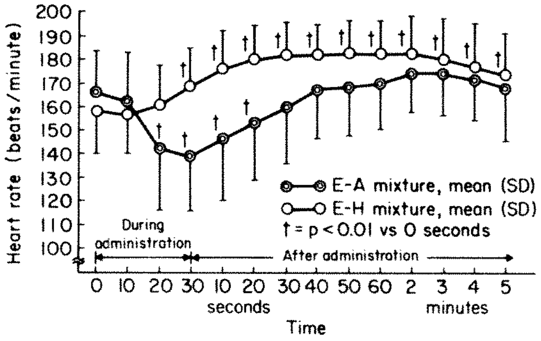

Fig. 1. Heart rate values expressed as mean (SD) during and after administration of edrophonium–atropine (E–A) and edrophonium–hyoscine butylbromide (E–H) mixtures.

Discussion

In adult studies,[4,5] it has been reported that E–A mixture causes no initial bradycardia, in contrast to edrophonium–glycopyrronium mixture. However, heart rate changes in these studies were not recorded until one minute after the administration of the mixture.

Atropine, when administered in mixture with edrophonium, is not able to prevent an edrophonium-induced bradycardia in infants and children. Consequently, it has been advocated that atropine should be administered 30 seconds before edrophonium to prevent bradycardia.[2] The administration of atropine before edrophonium has also been recommended in adults.[6] However, one of the advantages of the use of edrophonium rather than neostigmine in the clinical situation is the faster reversal and thus faster tracheal tube removal. The time to peak antagonism for edrophonium is reported to be 0.8–2.0 minutes;[6,7] however if edrophonium cannot be given until 30 seconds after atropine administration, the advantage of the rapid onset of action of edrophonium is reduced. Our results demonstrate that hyoscine butylbromide prevents bradycardia when administered in a mixture with edrophonium. The onset of action of hyoscine butylbromide is very rapid, and in contrast to atropine, there is no initial bradycardia after intravenous administration.[8]

Since hyoscine butylbromide is a quaternary ammonium compound, it does not cross the blood-brain barrier; this may be another potential advantage over atropine,[8] since atropine crosses the blood-brain barrier and can produce the central anticholinergic syndrome. Arousal time after neostigmine–glycopyrronium mixture is reported to be faster than that following neostigmine–atropine mixture;[9] this is believed to be because of the lack of a central cholinergic action of glycopyrronium.

In conclusion, hyoscine butylbromide can be used in infants and children as a substitute for atropine in edrophonium reversal of tubocurarine and, when given in a mixture with edrophonium, does not cause an initial bradycardia.

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References

1. Meakin G, Sweet PT, Bevan JC, Bevan DR. Neostigmine and edrophonium as antagonists of pancuronium in infants and children. *Anesthesiology* 1983; **59:** 316–21.

2. Fisher DM, Connelly R, Sharma M, Miller RD. Clinical pharmacology of edrophonium in infants and children. *Anesthesiology* 1984; **61**: 428–33.
3. Fry ENS. Hyoscine butylbromide: a useful premedicant. *Anaesthesia* 1975; **30**: 549–50.
4. Azar I, Pham AN, Karambelkar DJ, Lear E. The heart rate following edrophonium–atropine and edrophonium–glycopyrrolate mixtures. *Anesthesiology* 1983; **59**: 139–41.
5. Mirakhur RK. Antagonism of the muscarinic effects of edrophonium with atropine or glycopyrrolate. A comparative study. *British Journal of Anaesthesia* 1985; **57**: 1213–6.
6. Bevan DR. Reversal of pancuronium with edrophonium. *Anaesthesia* 1979; **34**: 614–9.
7. Cronnelly R, Morris RB, Miller RD. Edrophonium: duration of action and atropine requirement in humans during halothane anesthesia. *Anesthesiology* 1982; **57**: 261–6.
8. Grainger SL, Smith SE. Dose-response relationships of intravenous hyoscine butylbromide and atropine sulphate on heart rate in healthy volunteers. *British Journal of Clinical Pharmacology* 1983; **16**: 623–6.
9. Baraka A, Yared J-P, Karam A-M, Winnie A. Glycopyrrolate-neostigmine and atropine-neostigmine mixtures affect postanesthetic arousal times differently. *Anesthesia and Analgesia* 1980; **59**: 431–4.

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Induction characteristics of propofol in children: comparison with thiopentone

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Summary

The induction characteristics of propofol were studied and compared with thiopentone in children aged 3–14 years who received either no premedication or pethidine–atropine or trimeprazine. Anaesthesia was maintained with nitrous oxide in oxygen, and isoflurane. The induction doses of propofol and thiopentone were 2.9 mg/kg and 6.5–7.1 mg/kg respectively; premedication had no significant effect on the induction doses of either agent. Spontaneous movement and hypertonus occurred in about 20% of children with both agents. The use of propofol was associated with a high incidence of pain on injection (injections were mostly in veins on the dorsum of the hand), but this was reduced by mixing lignocaine with propofol. Cardiovascular effects were not clinically significant with either agent. Apnoea occurred in 35% of patients given propofol and in 50% of those given thiopentone. Children anaesthetised with propofol awoke significantly earlier after cessation of all anaesthesia. It is concluded that the use of propofol is safe in children and may have advantages where early recovery from anaesthesia is desirable, but offers no advantage over thiopentone for routine induction of anaesthesia.

Key words

Anaesthetics, intravenous; propofol, thiopentone.
Anaesthesia; paediatric.

Propofol is a rapidly-acting, intravenous anaesthetic agent, which was previously formulated in Cremophor, but is now reformulated as an aqueous emulsion in soya bean oil in order to minimise the occurrence of anaphylactoid reactions. It has been shown to induce anaesthesia smoothly in adults and is associated with a rapid and smooth recovery.[1–4] A previous study in children indicated that propofol may be useful as an induction agent in this age group.[5] However, this preliminary study was confined to only a small number of children, who were relatively older. In addition the influence of different premedications was not examined. In the present study, the usefulness of propofol has been assessed for induction of anaesthesia with or without premedication, in children aged 3–14 years. Propofol was compared with thiopentone, which remains the most commonly used induction agent.

Patients and methods

One hundred and twenty children aged 3–14 years were included in the study following approval from the Regional Ethics Committee and written informed consent from the parents. Three children conformed to ASA grade 2; two were suffering from mild bronchial asthma and required occasional inhalation of salbutamol, but were not receiving routine therapy; and the third had cerebral palsy. All other children were classified as grade 1. The majority were scheduled to undergo surgery for squint correction, although some were to have minor general surgical procedures.

Eighty children were allocated to receive induction of anaesthesia with either propofol or thiopentone after premedication with either trimeprazine 2.0 mg/kg orally 2 hours before, or pethidine 1.0 mg/kg and atropine 0.01 mg/kg intramuscularly one hour before, induction of anaesthesia. Twenty children were allocated randomly to each of these four groups. The remaining 40 children received no premedication but were allocated randomly to receive propofol or thiopentone for induction.

Each child was allowed to settle for about 10 minutes on arrival in the anaesthetic room, during which time electrocardiograph electrodes and the cuff of an oscillometer

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(Dinamap) were applied and heart rate and blood pressure recorded. A vein was then cannulated and the induction agent injected over a period of 20–30 seconds; the injection was titrated to the loss of eyelash reflex and/or failure to respond to verbal communication. The facemask was applied at this stage and the child allowed to breathe 66% nitrous oxide in oxygen for the next 5 minutes. Ventilation was assisted gently, if required. Heart rate and blood pressure were recorded every minute. Isoflurane was administered at the end of 5 minutes in addition to nitrous oxide in oxygen. The majority of children received suxamethonium 1.0 mg/kg for tracheal intubation, and subsequently breathed spontaneously. Three children were given vecuronium and their lungs ventilated with nitrous oxide, oxygen and isoflurane; at the end of the procedure, the effect of vecuronium was antagonised with neostigmine.

It was decided at the halfway point in the study to administer propofol mixed with lignocaine (1.0 mg per ml propofol) because of a high incidence of pain on injection of propofol.

Careful note was made of induction characteristics such as occurrence of spontaneous movement, hypertonus, hiccoughs or apnoea, and the incidence and severity of pain on injection. These criteria were used to grade induction of anaesthesia as good (absence of side effects), adequate (some side effects not interfering with induction) or poor (when the side effects were severe or protracted). The time taken for the patients to awaken spontaneously after cessation of anaesthesia was noted by the recovery ward staff who were not aware of the induction agent given. The patients were visited postoperatively on the same day and 24 hours later to record the occurrence of any nausea or vomiting and for examination of the injection site. Venous blood samples were withdrawn before induction of anaesthesia and between 6 and 24 hours after surgery for haematological and biochemical measurements.

Changes in arterial pressure and heart rate were subjected to analysis of variance and *t* tests. Nonparametric data were analysed by Fisher's Exact test. The Wilcoxon Signed Rank test was applied to the analysis of within-group changes in haematological and biochemical measurements and the Wilcoxon Rank Sum test to the analysis of between-group changes.

Results

The 120 patients in the study were divided into six groups of 20 each, and were comparable in age and weight (Table 1) with no significant differences among groups. The details of injection of the induction agents are shown in Table 2. The majority of injections were made on the dorsum of the hand and the mean induction doses of propofol and thiopentone were 2.9 and 6.5–7.1 mg/kg respectively. The induction dose of propofol was the same irrespective of whether the children were premedicated or not. The induction dose of thiopentone was slightly less in those given pethidine–atropine premedication (6.5 mg/kg in comparison to 7.0 and 7.1 mg/kg) but the differences between induction dose in these patients and in those who received trimeprazine or no premedication were not significant. Anaesthesia was induced with either agent in mean times of 25–28 seconds.

The incidence of the common side effects during induction is shown in Table 3. These occurred with similar frequency after both thiopentone and propofol; spontaneous movements and hypertonus were the most common, and were noted in about 20% of patients. Flushing occurred in six patients, all of whom received propofol. Once again there was no difference attributable to premedication. However, the incidence of apnoea did vary with premedication (Table 4). Apnoea occurred in 12 out of 20 patients (60%), who received propofol after pethidine–atropine premedi-

Table 1. Demograhic details.

	Premedication		No premedication
	Trimeprazine	Pethidine–atropine	
Propofol			
Age, years (SD)	6.1 (2.9)	6.9 (2.7)	7.1 (2.8)
Weight, kg (SD)	21.0 (7.1)	21.5 (5.6)	25.0 (10.0)
Males:females	10:10	9:11	11:9
Thiopentone			
Age, years (SD)	6.3 (2.2)	6.0 (1.5)	6.8 (1.8)
Weight, kg (SD)	22.6 (5.6)	22.3 (5.9)	23.3 (6.5)
Males:females	13:7	13:7	11:9

Table 2. Details of injection of induction agents.

	Premedication		No premedication
	Trimeprazine	Pethidine–atropine	
Propofol			
Site of injection			
Dorsum of hand, *n*	17	17	18
Antecubital fossa, *n*	2	3	2
Other, *n*	1	0	0
Induction dose, mg/kg (SD)	2.9 (0.4)	2.9 (0.3)	2.9 (0.3)
Induction time, seconds (SD)	25 (4)	27 (4)	27 (2)
Thiopentone			
Site of injection			
Dorsum of hand, *n*	19	18	17
Antecubital fossa, *n*	1	2	2
Other, *n*	0	0	1
Induction dose, mg/kg (SD)	7.0 (0.8)	6.5 (1.2)	7.1 (1.3)
Induction time, seconds (SD)	26 (5)	26 (4)	28 (6)

Table 3. Side effects during induction.

	Propofol ($n = 60$)	Thiopentone ($n = 60$)
Spontaneous movement	13	14
Hypertonus	11	10
Hiccough	2	2
Coughing	2	1
Flushing	6	0

cation, and this incidence was significantly greater than those following trimeprazine or no premedication. The incidence of apnoea was not influenced significantly by premedication with thiopentone induction. The overall incidence of apnoea after propofol and thiopentone did not differ significantly, but apnoea was significantly more frequent following pethidine–atropine premedication than trimeprazine when data from both induction groups were combined. The number of patients who were apnoeic for more than 30 seconds was highest (50%) in pethidine–atropine premedicated patients given propofol.

The incidences of pain on injection of the induction agents are shown in Fig. 1. The overall incidence of pain on injection of propofol (23 out of 60 patients, 38%) was significantly higher than that which followed thiopentone (2 out of 60, 3%). Further analysis of data in the propofol group shows a significantly lower incidence of pain in those given the drug in a mixture with lignocaine in comparison to those without lignocaine (17 and 60% respectively). However, the incidence of pain on injection of propofol even in a mixture with lignocaine is significantly higher than that associated with injection of thiopentone.

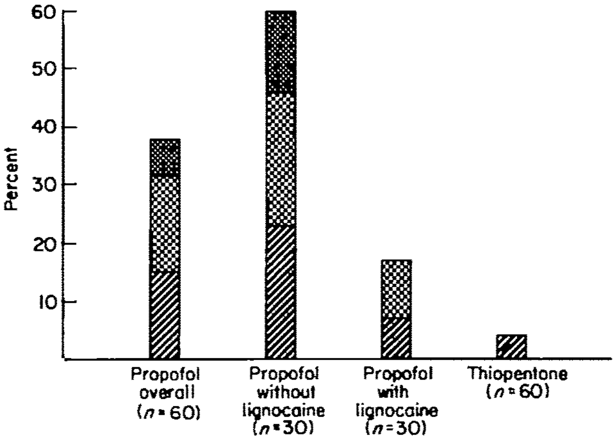

Fig. 1. Incidence of pain on injection: mild, ▨; moderate, ▒; severe, ▩.

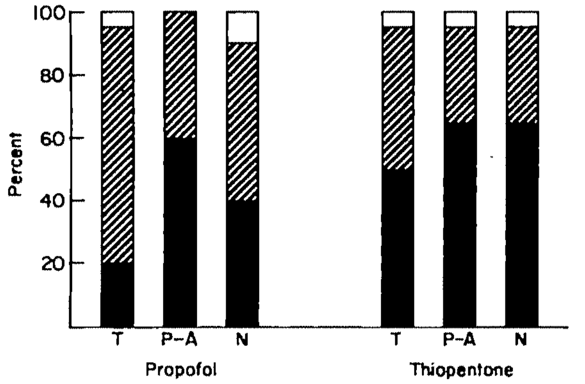

Fig. 2. Quality of induction: good, ■; adequate, ▨; poor, □. T, trimeprazine premedication; P–A, pethidine–atropine premedication; N, no premedication.

The overall assessment of inductions is shown in Fig. 2. Ninety-five percent were acceptable (either good or adequate). The number of inductions rated as good was significantly higher following thiopentone. More inductions with propofol were rated good in children premedicated with pethidine–atropine, but the difference due to premedications was not significant.

The heart rate and systolic arterial pressure are shown in Tables 5 and 6 respectively. The baseline heart rates were highest in those premedicated with pethidine–atropine. The changes in heart rate after propofol were mostly of no clinical significance, although there was a small but significant increase at one minute in those who received trimeprazine or no premedication, and a significant decrease at 3–5 minutes in those who received pethidine–atropine premedication. There was a significant increase in heart rate after thiopentone in all three groups at one minute and a small but significant decrease in the pethidine–atropine group at 4 and 5 minutes. There were significant but clinically acceptable decreases in systolic arterial pressure after both induction agents in patients who received either no premedication or pethidine and atropine.

The duration of anaesthesia and the time to spontaneous awakening are shown in Table 7. The average duration of anaesthesia was about 40 minutes in the premedicated groups and about 35 minutes in the unpremedicated groups, but the differences were not significant. The time to spontaneous awakening was significantly shorter in children who received propofol (11.3–13.6 minutes in comparison to 16.1–22.3 minutes with thiopentone).

There were small but statistically significant decreases in haemoglobin concentration, packed cell volume, and total protein, albumin and alkaline phosphatase concentrations, and small, but significant increases in the white cell count and urea and creatinine concentrations in the postoperative samples after both induction agents (Table 8). However,

Table 4. Incidence and duration of apnoea.

	Premedication		No premedication
	Trimeprazine	Pethidine–atropine	
Propofol			
Apnoea, *n*	5	12	4
> 30 seconds *n*	3	10	2
Mean duration, seconds (SD)	36 (18)	78 (66)	28 (12)
Thiopentone			
Apnoea, *n*	7	11	12
> 30 seconds, *n*	4	6	7
Mean duration, seconds (SD)	34 (17)	49 (45)	34 (16)

No significant difference in the incidence of apnoea between propofol and thiopentone. Overall incidence of apnoea significantly higher after pethidine–atropine premedication in comparison to trimeprazine ($p < 0.05$).

Table 5. Heart rates during induction, beats/minute (SD).

	Premedication		No premedication
	Trimeprazine	Pethidine–atropine	
Propofol			
Baseline	110 (31)	123 (22)	103 (25)
1 minute	130 (19)*	123 (27)	112 (21)*
2 minutes	116 (21)	112 (19)*	103 (21)
3 minutes	112 (24)	105 (14)†	94 (17)
4 minutes	110 (25)	104 (12)†	93 (19)
5 minutes	118 (29)	110 (14)*	95 (24)
Thiopentone			
Baseline	103 (27)	124 (26)	103 (28)
1 minute	121 (17)**	131 (19)*	126 (18)†
2 minutes	113 (19)	123 (19)	112 (19)*
3 minutes	109 (15)	119 (19)	106 (15)
4 minutes	106 (15)	115 (19)*	104 (16)
5 minutes	108 (15)	114 (20)*	102 (23)

Difference significant from respective baseline values, * $p < 0.05$, ** $p < 0.01$, † $p < 0.001$.

Table 6. Systolic arterial pressure, mmHg (SD).

	Premedication		No premedication
	Trimeprazine	Pethidine–atropine	
Propofol			
Baseline	116 (13)	122 (12)	120 (16)
1 minute	118 (14)	111 (10)**	113 (10)
2 minutes	115 (13)	109 (14)**	111 (8)*
3 minutes	108 (14)	102 (10)†	106 (12)**
4 minutes	105 (12)**	102 (11)†	102 (9)†
5 minutes	109 (15)	103 (10)†	105 (8)**
Thiopentone			
Baseline	118 (16)	125 (13)	123 (9)
1 minute	118 (18)	120 (11)*	122 (16)
2 minutes	117 (18)	117 (14)*	115 (14)
3 minutes	117 (17)	113 (12)**	110 (12)**
4 minutes	113 (17)	109 (7)†	111 (12)**
5 minutes	113 (14)	110 (12)†	111 (17)**

Difference significant from respective baseline values, * $p < 0.05$, ** $p < 0.01$, † $p < 0.001$.

Table 7. Duration of anaesthesia and time to awakening, minutes (SD).

	Premedication		No premedication
	Trimeprazine	Pethidine–atropine	
Propofol			
Duration of anaesthesia	39.6 (9.6)	41.4 (13.3)	34.7 (29)
Time to waking	13.6 (6.3)	11.3 (5.3)	11.6 (7.0)
Thiopentone			
Duration of anaesthesia	39.1 (10.4)	41.5 (10.1)	34.7 (24.1)
Time to waking	21.7 (8.1)	22.3 (10.8)	16.1 (7.3)

Differences significant ($p < 0.05$) in the waking time between thiopentone and propofol.

not only were both pre-operative and postoperative values for all haematological and biochemical parameters within the normal laboratory range for this age group, but many of the changes were within the coefficient of variation of the laboratory assays.

The incidence of immediate postoperative nausea was significantly less with propofol (2 out of 60) in comparison to thiopentone (11 out of 60) but there was no difference in the incidence of vomiting (12 out of 60 with each agent). Over the 24-hour period, vomiting occurred in a total of only 10 patients in the study, with no significant difference between the induction agents. Examination of the injection site after 24 hours showed mild phlebitis in one patient given propofol and in seven given thiopentone.

Discussion

The present study was carried out to assess the suitability of propofol for induction of anaesthesia in children, to compare it with thiopentone, and to identify any differences in the induction characteristics of propofol in this age group in comparison with adults. The average induction dose of 2.9 mg/kg in children is higher than the average dose of about 2.5 mg/kg reported in adults.[1,3,4,6–8] This need for higher doses indicates reduced sensitivity in children. In contrast, there is increased sensitivity and a reduced dose requirement in the elderly.[8,9] Premedication appeared to have no influence on the induction dose of propofol; this has been reported previously in studies of adult patients.[2,10,11] The

Table 8. Laboratory investigations. Values expressed as mean (SD).

	Propofol (n = 54)		Thiopentone (n = 53)	
	Before operation	After operation	Before operation	After operation
Haemoglobin (g/dl)	12.7 (1.0)	12.4 (1.0)*	12.9 (0.9)	12.5 (0.9)*
Packed cell volume	0.38 (0.03)	0.37 (0.03)*	0.39 (0.03)	0.37 (0.03)*
Platelets (10^9/litre)	350 (93)	356 (107)	346 (73)	341 (78)
WCC (10^3/litre)	8.1 (2.4)	8.9 (2.2)*	7.6 (1.9)	8.6 (2.3)*
Urea (mmol/litre)	4.8 (1.4)	5.7 (1.7)*	4.4 (1.3)	5.1 (1.6)*
Creatinine (μmol/litre)	47.7 (8.9)	51.3 (9.4)*	47.0 (7.1)	50.2 (7.4)*
Total proteins (g/litre)	69.8 (4.1)	66.8 (4.8)*	70.1 (4.2)	67.5 (4.5)*
Albumin (g/litre)	45.4 (2.9)	43.8 (3.6)*	45.5 (2.6)	44.1 (2.9)*
Bilirubin (μmol/litre)	8.3 (3.6)	8.4 (4.3)	7.0 (2.6)	7.7 (3.9)
ALP (u/litre)	263 (236)	253 (221)*	239 (78)	230 (74)*
AST (u/litre)	28 (6)	30 (7)	27 (6)	29 (7)
ALT (u/litre)	17.3 (6.7)	16.5 (7.2)	16.6 (7.3)	17.0 (7.5)

WCC, white cell count; ALP, alkaline phosphatase; AST, aspartate transaminase; ALT, alanine transaminase; * Significantly different ($p < 0.05$) from the respective pre-operative value.

only other paediatric study (in a small number of older children) suggested that a dose of 2.0 mg/kg of propofol was sufficient to induce anaesthesia after a more sedative premedication with papaveretum and hyoscine.[5] It is clear that the dose of thiopentone required for induction of anaesthesia in this age group is also higher than in adults. This has been reported previously by Duncan *et al.*[12] who found the induction dose of thiopentone to be 10.5 mg/kg in unpremedicated children. There was only a minimal reduction in the dose requirements of thiopentone in the present study when children were premedicated with pethidine–atropine, although Duncan and her colleagues reported large and significant reductions in those premedicated with trimeprazine–droperidol–methadone–atropine, papaveretum–hyoscine or with trimeprazine–atropine mixtures.[12] Trimeprazine premedication in a dose of 2 mg/kg in the present study did not lead to any reduction in the induction dose of thiopentone. A significant effect in the study of Duncan *et al.*[12] may have resulted from the use of 3.0 mg/kg of trimeprazine. However, such doses of trimeprazine have been shown to lead to excessive cardiovascular depression.[13]

The present study showed that the potency ratio between propofol and thiopentone in children is approximately 1:2.4 in comparison to the commonly accepted potency ratio of 1:2,[7,8,14] although one report has suggested a potency ratio of 1:1.6.[15] This indicates that although the requirements for both propofol and thiopentone are higher in children, the requirements for thiopentone increases proportionately more. Dose requirements for a number of drugs are increased in this age group, possibly because of the high extracellular fluid volume in children.

In their initial study of propofol in children, Purcell-Jones and James[5] recorded an incidence of spontaneous movements as high as 65%. In the present study, however, both spontaneous movement and hypertonus were observed in about 20% of children with each of the induction agents. This is a similar incidence to that observed with propofol in adults,[1,7] although some observers have recorded lower frequencies.

Pain on injection is not an uncommon observation with the use of propofol, although its incidence is less with the use of emulsion formulation in comparison with the previous Cremophor formulation. It varies with the size of the vein into which the drug is injected and consequently is more frequent after injection into the veins in the dorsum of the hand. McCollum and Dundee[7] recorded incidences of 31% and 8% after injection of propofol in the veins on the dorsum of the hand and the antecubital fossa respectively. It is not surprising that the incidence of pain was so high in the present study, because propofol was given mostly into the even smaller veins on the dorsum of children's hands. Addition of lignocaine produced a significant reduction in the incidence of pain. Prior injection of lignocaine has been recommended previously for pain reduction with methohexitone,[16] but it was administered mixed with propofol in the present study following observations of Brooker *et al*,[17] who showed that a lignocaine–propofol mixture was associated with less pain than when lignocaine was given before propofol. However, it was disappointing to find that in spite of significant pain reduction by the addition of lignocaine, the incidence still remained higher than with thiopentone. It may be possible to achieve further pain reduction by using relatively larger veins in the forearm or the antecubital fossa. The pain on injection is likely to have contributed to fewer 'good' inductions attained with propofol.

Respiratory depression or apnoea is another common observation after propofol administration in adults.[1,2,7,9,18] Contrary to the findings of Taylor *et al.*,[18] it occurred with slightly greater frequency in the present study with thiopentone, but not unexpectedly was more frequent and longer lasting after pethidine–atropine premedication. Surprisingly, apnoea after thiopentone administration occurred with the same frequency in those who received no premedication as those who received a pethidine–atropine premedication. This may reflect the greater likelihood of patients in this age group to develop respiratory depression following intravenous anaesthesia.

Significant cardiovascular depression in terms of decreases in arterial pressure is a wellknown feature of propofol in adults and the elderly.[3,7,9,19,20] There was a significant reduction in systolic arterial pressure with propofol in children, particularly in those premedicated with pethidine–atropine, but it was less than is commonly observed in adults, and was within clinically acceptable limits. Changes in heart rate were generally of slightly lesser magnitude with propofol and remained mostly within clinically acceptable limits.

Early recovery from anaesthesia, though more important in daycase surgical patients, is a desirable feature after any operation. Not only does it ensure the overall safety of patients, but it also reduces the requirement for intensive nursing. A consistent feature of the use of propofol has been early recovery, and this has been demonstrated in many studies.[3,21,22] Overall recovery also depends upon the use of other drugs during anaesthesia. In the present study, anaesthesia was maintained with nitrous oxide in oxygen and isoflurane and the same maintenance anaesthetic regimen was used in all patients. The present study was not designed specifically to examine recovery, but it is clear that with even the crude parameter of spontaneous awakening, the use of propofol was associated with an earlier recovery.

The use of propofol is reported to be associated with a low incidence of postanaesthetic emetic sequelae.[21,23] In the present study, a significantly lower incidence of nausea was observed with propofol but the incidence of vomiting was the same with thiopentone and propofol. It has even been suggested that propofol has an antiemetic effect.[24] However this appears to be unlikely in patients who undergo squint surgery.[25]

The haematological and biochemical indices were within normal limits both before and after operation although there were statistically significant changes in some of these.

In conclusion, propofol induces anaesthesia in children at an average dose of 2.9 mg/kg. Its use is associated with a high incidence of pain on injection which can be reduced by addition of lignocaine. It is safe in children and is associated with less cardiovascular depression than in adults. It offers no significant advantages over thiopentone, although early recovery may be useful in day stay surgical patients.

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References

1. Cummings, GC, Dixon J, Kay NH, Windsor JPW, Major E, Morgan M, Sear JW, Spence AA, Stephenson DK. Dose requirements of ICI 35,868 (Propofol, 'Diprivan') in a new formulation for induction of anaesthesia. *Anaesthesia* 1984; **39:** 1168–71.
2. Nightingale P, Healy TEJ, Hargreaves J, McGuiness K, Kay B. Propofol in emulsion form: induction characteristics and venous sequelae. *European Journal of Anaesthesiology* 1985; **2:** 361–8.
3. Mackenzie N, Grant IS. Comparison of the new emulsion formulation of propofol with methohexitone and thiopentone for induction of anaesthesia in day cases. *British Journal of Anaesthesia* 1985; **57:** 725–31.
4. Edelist G. A comparison of propofol and thiopentone as induction agents in outpatient surgery. *Canadian Journal of Anaesthesia* 1987; **34:** 110–6.
5. Purcell-Jones G, James IG. The characteristics of propofol ('Diprivan') for induction of general anaesthesia for paediatric surgery (Abstract). *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 115.
6. Grounds RM, Morgan M, Lumley J. Some studies on the properties of the intravenous anaesthetic, propofol ('Diprivan')—a review. *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 90–5.
7. McCollum JSC, Dundee JW. Comparison of induction characteristics of four intravenous anaesthetic agents. *Anaesthesia* 1986; **41:** 995–1000.
8. Dundee JW, Robinson FP, McCollum JSC, Patterson CC. Sensitivity to propofol in the elderly. *Anaesthesia* 1986; **41:** 482–5.
9. Mirakhur RK, Shepherd WFI. Intraocular pressure changes with propofol ('Diprivan'): comparison with thiopentone. *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 41–4.
10. Briggs LP, White M. The effects of premedication on anaesthesia with propofol ('Diprivan'). *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 35–7.
11. Bilaine J, Desmonts JM. Effect of premedication with atropine or hydroxyzine on induction and maintenance of anaesthesia with propofol ('Diprivan') (Abstract). *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 38–9.
12. Duncan BBA, Zaimi F, Newman GB, Jenkins JG, Aveling W. Effect of premedication on the induction dose of thiopentone in children. *Anaesthesia* 1984; **39:** 426–8.
13. Loan WB, Cuthbert D. Adverse cardiovascular response to oral trimeprazine in children. *British Medical Journal* 1985; **290:** 1548–9.
14. Grant IS, Mackenzie N. Relative potency of propofol and thiopentone. *Anaesthesia* 1987; **42:** 317–8.
15. Grounds RM, Moore M, Morgan M. The relative potencies of thiopentone and propofol. *European Journal of Anaesthesiology* 1986; **3:** 11–7.
16. Millar JM, Marshall Barr A. The prevention of pain on injection. A study of the effect of intravenous lignocaine before methohexitone. *Anaesthesia* 1981; **36:** 878–80.
17. Brooker J, Hull CJ, Stafford M. Effect of lignocaine on pain caused by propofol injection. *Anaesthesia* 1985; **40:** 91–2.
18. Taylor MB, Grounds RM, Mulrooney PD, Morgan M. Ventilatory effects of propofol during induction of anaesthesia. Comparison with thiopentone. *Anaesthesia* 1986; **41:** 816–20.
19. Mirakhur RK, Shepherd WFI, Darrah WC. Propofol or thiopentone: effects on intraocular pressure associated with induction of anaesthesia and tracheal intubation (facilitated with suxamethonium). *British Journal of Anaesthesia* 1987; **59:** 431–6.
20. Fahy LT, Van Mourik GA, Utting JE. A comparison of the induction characteristics of thiopentone and propofol (2,6-di-isopropyl phenol). *Anaesthesia* 1985; **40:** 939–44.
21. O'Toole DP, Milligan KR, Howe JP, McCollum JSC, Dundee JW. A comparison of propofol and methohexitone as induction agents for day case isoflurane anaesthesia. *Anaesthesia* 1987; **42:** 373–6.
22. Kay, B, Hargreaves J, Sivalingam, T, Healy TEJ. Intravenous anaesthesia for cystoscopy: a comparison of propofol or methohexitone with alfentanil. *European Journal of Anaesthesiology* 1986; **3:** 111–20.
23. Stark RD, Binks SM, Dutka VN, O'Connor KM, Arnstein MJA, Glen JB. A review of the safety and tolerance of propofol ('Diprivan'). *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 152–6.
24. McCollum JSC, Milligan KR, Dundee JW. Has propofol an antiemetic action? *British Journal of Anaesthesia* 1987; **59:** 654-5P.
25. Van den Berg AA, Lambourne A, Yazji NS, Laghari NA. Vomiting after ophthalmic surgery. Effects of intra-operative antiemetics and postoperative oral fluid restriction. *Anaesthesia* 1987; **42:** 270–6.

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The Editor 615

Dreaming and anaesthesia

The study by O'Sullivan *et al.* (*Anaesthesia* 1988; **43:** 104–6) into children anaesthetised with 0.7 minimal alveolar concentration (MAC) of nitrous oxide and the subsequent incidence of dreaming during surgery surprised me, because only 9.7% of cases reported dreaming and there was no spontaneous recall of intra-operative events. There have been previous studies into the validity and indeed morality of balanced anaesthesia[1] and one would have hoped that that approach was superseded.

The patient is 'free' to leave the theatre should he find the procedure unpleasant under inhalational anaesthesia; that is to say, he is not in the pharmocological straitjacket of neuromuscular blockade. Once neuromuscular blocking drugs are given we, as attending physicians with respon-

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sibility for the patient's wellbeing, must ensure that the patient is totally unaware of the procedure and not just banished to some terror world of hallucinations. If we assume that at 1 MAC, 50% of our patients do not move in response to surgical stimulation then we could assume that they are not aware. At 1.2–1.3 MAC few patients move.[2] Therefore surely we should aim to attain a MAC of 1.6 to cover our entire population, double that attained in this study.

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References

1. RUSSELL IF. Balanced anaesthesia: does it anaesthetize? *Anesthesia and Analgesia* 1985; **64:** 941–2.
2. EGER EI. Isoflurane: a review. *Anesthesiology* 1981; **55:** 559–76.

A reply

Thank you for giving us the opportunity to reply to the letter from Dr B. O'Sullivan about the incidence of dreaming and anaesthesia in children.

It is important to stress that, as mentioned in our article, no case of awareness was elicited in the patients in this study. This finding agrees with previous work undertaken by Dr Pledger some 25 years ago using a similar technique in Liverpool. Furthermore, because of our concern that a recent increase in daycase surgery has resulted in the use of fewer premedicant drugs, with the possibility therefore of awareness, a study was undertaken and the result is published in this number (p. 560). This confirmed that no patient was aware during these procedures using this technique of anaesthesia. Obviously, no anaesthetic technique can be contemplated should the possibility of awareness exist. The whole question of validation and meaning of minimal alveolar concentration (MAC) requires much greater study and cannot be defined solely in terms of concentration of inhalational agents, nor can it be applied to a single aspect of the anaesthetic state.

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Technical exhibitions

Many consultants may be asked to help organise a meeting. Three vital questions are usually asked at the first assembly of the organising committee. What programme should be offered, how many delegates will come and how much will it cost? When the provisional budget is developed a major source of income will be that earned from 'The Trade' and usually a technical exhibition is an essential part of the meeting. Recently, some organisers reported a decline in the number of commercial organisations exhibiting. It is therefore important to examine the relationships between exhibiting firms and the profession to discover what each requires.

A firm allocates a certain sum from its annual budget for exhibition purposes, usually a year in advance; this budget has to cover the cost of the exhibition space, travel, hotel and the other expenses of representatives. Expenses can increase considerably if the meeting is on a Saturday or Sunday. Thus, meetings which give plenty of advance publicity and take place during the working week have a greater chance of support. The likelihood and degree of help is increased if a fee, which is reasonable rather than outrageous, is set for exhibition space.

The number of new societies and meetings have escalated over the last decade; each new one soliciting support for its special event. Indeed, a large number of local, regional, specialist, national and international meetings occur each year in the UK so that it is essential for firms to be selective since they could not afford to exhibit at every one.

The next consideration is the history of the meeting. The chances of continued support are high if the last occasion was well attended and many delegates visited the trade exhibition so that the firms saw substantial benefit. This is an important point for the organiser of the next meeting but it should come as no surprise if support for it is not forthcoming if the attendance was scant and little interest shown. Firms expect value for money when they support a meeting. It is important to show a plan of the area to indicate where the exhibition lies in relationship to other facilities particularly lecture theatres and refreshment facilities. The nearer to both the better. Coffee and tea should be served in the exhibition area during the morning and afternoon breaks and lunch is often provided nearby. The exhibitors' personnel have also to eat and drink so these requirements are part of the organiser's arrangements.

Delegates who attend a meeting are usually directed by signposts to a registration desk where they are given verbal and written details about the form and layout. The exhibitors, who usually arrive earlier, may have no clear directions or any indication of the person to whom they should direct their enquiries. It seems reasonable that a member of the organising committee be allocated the responsibility of dealing with them so that any problem, large or small, can be dealt with smoothly and rapidly by someone who knows the area well. This person should also remember that anaesthetic and intensive care equipment is both bulky and heavy so that reasonable access for exhibitors' transport should be allowed both immediately before and after the meeting.

It is essential to ensure that the registrants know where the exhibition is situated and that the route to it is clearly marked. The stands themselves are usually well designed and have many features to draw the delegate; thereafter it is between the doctor and the exhibitor. It is at this interface that the doctor is exposed to recent and, possibly, exciting new developments. Sufficient time must be allowed for delegates to visit the exhibition and allowance should be made in the programme for delays caused either by the conference itself or by other activities of the people attending. The chairperson should always remind the delegates to visit the exhibition at the end of each scientific session.

What of the organisers? Each president of the Association of Anaesthetists leads by example and visits each stand. The President also hosts a special reception which coincides with the opening of the exhibition; at the Annual Scientific Meeting he welcomes all the exhibitors and thanks them for their support. It seems reasonable therefore to expect that every delegate should also try to visit each stand. The discussions which follow are generally beneficial to both parties. For the exhibitor, there is nothing worse than manning a stand at which no delegate stops to talk: I have been in such a position and it is soul destroying.

There seemed at a recent meeting a certain reluctance by delegates to follow their natural instincts to visit each stand. I asked a delegate whom I know well, why? He replied that he felt embarrassed because his District had no money to spend on new equipment and he would be wasting the representative's time. That was out of a budget in excess of £150 million in his district! Each anaesthetist should insist that obsolete equipment be replaced when its natural lifespan has ended and that some development monies should be available each year to keep up with the important changes in the state of the art. We owe it to our patients not to use outdated equipment. Certainly, if anything goes wrong and litigation follows, it is not only the Health Authorities who will be blamed for using faulty or obsolete equipment.

In summary, when planning a meeting let the industrial representatives have a plan of the exhibition area, a programme and all the relevant correspondence concerned with the meeting. One member of the organising committee should accept total responsibility for the technical exhibition so that any difficulties can be ironed out *quam celerime*. It is only by such friendly efficiency that the excellent symbiotic relationship between anaesthetists and the industry can continue to be fruitful for all—especially the patient.

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Patients' perceptions of obstetric anaesthetic services

Some months ago the Committee of The Obstetric Anaesthetists' Association decided to seek information about patients' perceptions of obstetric anaesthetic services. Three hospitals (*vide infra*) were chosen to ascertain if patients views varied nationally.

A questionnaire was presented to patients either at the antenatal clinic, in the antenatal wards or at parent craft classes. The patients were divided into three groups: Group A, 265 primigravida; Group B, 242 multigravida who had had an obstetric anaesthetic service in one of their previous pregnancies i.e. either epidural analgesia for labour, or epidural, spinal or general anaesthetic for operative delivery; Group C, 241 multigravida who had perfectly normal deliveries previously without any obstetric anaesthetic intervention.

There was no statistically significant difference in the answers from the three different hospitals which itself is interesting. There were also no significant differences between the answers from each group of patients. Ninety percent of patients knew what an anaesthetist was and 87% knew what general anaesthesia was, which is encouraging. Ninety-four percent knew what 'epidurals' were. This knowledge appears to be gleaned from magazines, relatives, friends and other patients. Only 5% think about anaesthetic help and availability when they book at a hospital. This is possibly because delivery is not imminent at that time. Ninety-four percent thought that every maternity unit should have readily available anaesthetic help and 92% thought that this help should be resident. Ninety-four percent of patients considered that epidurals should be available in every maternity unit.

Only 33% of patients appreciated the significance of an half-hour delay in obtaining an anaesthetist and would be willing to change their booking to another hospital, at which there was readily available anaesthetic cover. This may be because morbidity and mortality in relation to childbirth is low.[1] Therefore, the knowledge in the population about the risks must also be low; even multigravida with previous hospital admissions may have no personal experience to appreciate the potential danger of delay in obtaining an anaesthetist.

The patients were asked 'if epidurals were not available in the maternity unit where you booked to have your baby, and you wished to have the choice, would you change your booking to another hospital?' Forty-four percent said they would. An epidural service is not available in 75% of all units in the UK.[2] If 44% of patients were to change their booking to the remaining units this would greatly increase their workload. Health Authorities and Divisions of Anaesthesia should take note.

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References

1. DHSS. *29th report on confidential enquiries into maternal deaths in England and Wales 1979–81*. London: HMSO, 1986.
2. *Anaesthetic facilities at the place of birth*. National Birthday Trust, 1986.

Premenstrual asthma

R.J. Lenoir (*Anaesthesia* 1987; **42:** 1287–1290) describes three patients with severe premenstrual or menstrual asthma (PMA) who required ventilatory support to their lungs and implies that reduced endogenous progesterone levels may be a causative factor. Further studies which investigate the pattern of asthma during the reproductive years in women with PMA may be instructive. The author quotes Gibbs *et al.*[1] who found no correlation between PMA and asthma during pregnancy, when progesterone levels are high, although symptoms improved in 49% of pregnancies.

Asthma complicates 0.2%–1.3% of pregnancies and status asthmaticus occurs in 0.2% of cases.[2] Termination of pregnancy by Caesarean section has resulted in dramatic alleviation of status asthmaticus within 24 hours,[3] presumably when progesterone levels are decreasing. There is no clear evidence that progesterone relaxes bronchial smooth muscle during pregnancy although pulmonary mechanics are considerably altered.[4] Early studies suggested that specific airways conductance increased by 36% in normal subjects during the third trimester of pregnancy.[5] Milne, however, found no change in specific airways conductance during or after pregnancy or in one-second forced vital capacities throughout pregnancy.[6]

The pattern of asthma during pregnancy depends on many interactions between patient and environmental factors. Asthma deteriorates in 22% of pregnancies after 4 months' gestation, usually in women with severe preconception symptoms.[7] Gastro-oesophageal reflux complicates 50% of pregnancies, and progestational muscular relaxation of lower oesophageal sphincter tone may be a causal factor in some cases. The presence of acid in the oesophagus can trigger reflex bronchoconstriction which is probably neurally mediated[8] and antacids can be effective in relieving heartburn and bronchospasm. We have observed asthma to worsen in association with the development of heartburn during pregnancy often characterised by nocturnal wheezing when reflux symptoms are most prominent. An increase in asthma therapy with beta-adrenegic agonists and theophyllines may compound the problem by reducing lower oesophageal sphincter pressure[8] and causing increased acid reflux in this situation. Simple antacid therapy with regular magnesium trisilicate mixture improves symptoms of reflux and asthma in some of these cases and is the subject of an ongoing investigation.

Bronchoconstriction in response to oesophageal reflux of gastric acid could have broad implications in anaesthesia and intensive care. General principles of gastric emptying, H_2 antagonist and antacid therapy should be instituted in all high risk cases.

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References

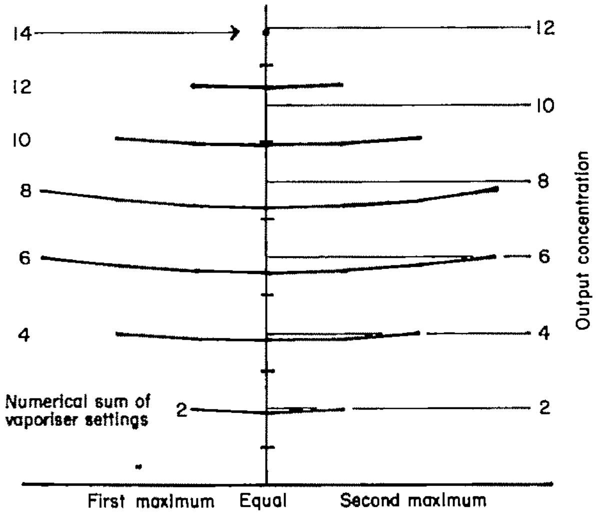
1. GIBBS CJ, COUTTS II, LOCK F, FINNEGAN OC, WHITE RJ. Premenstrual exacerbation of asthma. *Thorax* 1984; **39:** 833–6.
2. HERNANDEZ E. ANGELL CS, JOHNSON JWC. Asthma in pregnancy: current concepts. *Obstetrics and gynecology* 1980; **55:** 739–43.
3. GELBER M, SIDI Y, GASSNER S, OVADIA Y, SPITZER S, WEINBERGER A, PINKHAS J. Uncontrollable life-threatening status asthmaticus—an indicator of termination of pregnancy by Cesarean section. *Respiration* 1984; **46:** 320–2.
4. TURNER ES, GREENBERGER PA, PATTERSON R. Management of the pregnant asthmatic patient. *Annals of Internal Medicine* 1980; **93:** 905–18.
5. GEE JBL, PACKER BS, MILLEN JE, ROBIN ED. Pulmonary mechanics during pregnancy. *Journal of Clinical Investigation* 1967; **46:** 945–52.
6. MILNE JA. The respiratory response to pregnancy. *Postgraduate Medical Journal* 1979; **55:** 318–24.
7. GLUCK JG, GLUCK PA. The effects of pregnancy on asthma: a prospective study. *Annals of Allergy* 1976; **37:** 164–8.
8. BARISH CF, WU CW, CASTELL DO. Respiratory complications of gastroesophageal reflux. *Archives of Internal Medicine* 1985; **145:** 1882–8.

The calculation of output from two vaporizers in series

Drs Macmillan and Colville (*Anaesthesia* 1987; **42:** 1017) suggest that two identical vaporizers containing the same agent and used in series may be useful when depth of anaesthesia is required, but halothane is proscribed by a recent administration. Their measurements of the output of enflurane from vaporizers in series show that the final concentration is always less than the sum of the dial indicators at the flow rates quoted (5 and 7 litres/minute).

Table 1. This shows output (%) of enflurane from two identical vaporizers in series.

Vaporizer 1%	1	2	3	4	5	6	7
Vaporizer 2%							
1	1.96	2.91	3.87	4.83	5.79	6.74	7.70
2	2.91	3.91	4.74	5.66	6.57	7.48	8.40
3	3.87	4.74	5.61	6.48	7.36	8.23	9.10
4	4.83	5.66	6.48	7.31	8.14	8.97	9.80
5	5.79	6.57	7.36	8.14	8.93	9.71	10.50
6	6.74	7.48	8.23	8.97	9.71	10.45	11.20
7	7.70	8.40	9.10	9.80	10.50	11.20	11.90



The final output can be derived by calculating the splitting ratio[1] and then applying this to each vaporizer in turn. The equations simplify as shown below. Table 1 and Fig. 1 are derived from this equation which applies to any volatile agent. Theoretically the final concentration is independent of the flow rate. Perhaps surprisingly, it makes no difference in what order the vaporizers are set.

C_1 = concentration setting first vaporizer%; C_2 = concentration setting second vaporizer%; Cfin = final concentration of vapour%; Vb = flow bypassing plenum chamber; Vt = total flow through vaporizer; S = saturation concentration of volatile agent. (For practical purposes this is taken as the Saturated Vapour Pressure in kPa at sea level.)

$$\begin{aligned} \text{Cfin} &= (\text{S}(\text{Vt} - \text{Vb}) + \text{C}_1.\text{Vb})/\text{Vt} \\ &= \text{S}(\text{Vt}/\text{Vt}) - \text{SVb}/\text{Vt} + \text{C}_1.\text{Vb}/\text{Vt} \\ &= \text{S} - \text{S.Vb}/\text{Vt} + \text{C}_1.\text{Vb}/\text{Vt} \end{aligned} \tag{1}$$

but when $C_1 = 0$ then C_2 = Cfin

thus: $\text{S}(\text{Vt} - \text{Vb})/\text{Vt} = \text{C}_2$

hence: $$\text{Vb}/\text{Vt} = (\text{S} - \text{C}_2)/\text{S} \tag{2}$$

Substituting for Vb/Vt in Eqn (1):

$$\text{Cfin} = \text{S} - (-\text{C}_2)/\text{S} + \text{C}_1(\text{S} - \text{C}_2)/\text{S}$$

thus: $\text{Cfin} = \text{S} - \text{S} + \text{C}_2 + \text{C}_1 - (\text{C}_2.\text{C}_1)/\text{S}$

hence: $\text{Cfin} = \text{C}_2 + \text{C}_1 - (\text{C}_2.\text{C}_1)/\text{S}$

Thus the total output is the sum of the two settings, less the product of the settings divided by the saturation concentration.

We concur with Macmillan and Colville's recommendation that such high concentrations are only appropriate in spontaneously breathing patients where the depth of anaesthesia can be gauged clinically.

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Reference

1. LEIGH JM. Variations on a theme: splitting ratio. *Anaesthesia* 1985; **40:** 70–2.

Factor XII (Hageman) deficiency

A male patient aged 43 years was referred to me in the Anaesthetic Assessment Clinic. He was due to have surgery for varicose veins. He was very apprehensive because his sister had died after a pulmonary embolus following deep vein thrombosis after similar surgery for varicose veins, though the patient said he thought it was a very rare form of blood poisoning!

He gave a history of a laparotomy for volvulus of the stomach when aged 21 years but had no problems postoperatively or blood transfusion. He had had three episodes of swelling of his left leg after injury on the football field, and on one occasion was thought to have deep vein thrombosis although a venogram did not confirm this; he was anticoagulated with heparin for 4 days.

A clotting screen was requested which revealed a prolonged kaolin–cephalin clotting time of 59.9 seconds (control 39.7 seconds). Factor XII Assay (one stage) was carried out and was 0.20 μ/ml (normal range 0.36–1.52 μ/ml). Factor XII is responsible for activating the fibrinolytic system as well as the intrinsic clotting pathway, and although there are alternative physiological mechanisms for activating clotting, there are no such mechanisms for activating fibrinolysis.

This condition is sufficiently rare for there to be little information available in books or journals as to how to manage such a patient. The haematological advice (Dr D. Edwards) was that operation should be avoided unless absolutely necessary. If operation is unavoidable the deficient factor should be replaced with fresh frozen plasma before operation and in the postoperative period until the patient's mobility is restored and healing of the wounds has taken place.

The patient and his wife agreed after discussion not to proceed with surgery and two other family members will be investigated fully. It would be interesting to hear of others' experience with this condition.

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Safe anaesthesia: pulse oximetry for all?

The safety record of anaesthesia in the United Kingdom is very good, although the mortality from anaesthesia is approximately 1:10 000.[1,2] It is a catastrophe if death or cerebral damage result from undetected or mismanaged hypoxia. The clinical signs of hypoxia during anaesthesia are well known but may be difficult to detect. Clearly oxygen monitoring during anaesthesia is necessary. What should be measured and where should it be measured?

In theory, the brain requires a mitochondrial oxygen tension $P\mathrm{O}_2$ of more than 0.25 kPa. Routine intracullular oxygen measurements are not possible, but cerebral venous $P\mathrm{O}_2$ measured in the internal jugular vein is; the minimum theoretical value indicating adequate cerebral oxygenation being 2.5 kPa. The arterial $P\mathrm{O}_2$ at which cerebral venous $P\mathrm{O}_2$ remains above this may vary widely, (but may be measured noninvasively) and the margin of safety greatly reduced if any factors determining the delivery of O_2 to the tissues are compromised. The question that arises is what is the most useful monitor of imminent cerebral hypoxia long before cerebral damage may occur.

The importance of monitoring the oxygen supply to the patient cannot be overemphasised. This requires an oxygen monitor between the anaesthetic machine and the patient with alarms set appropriately. Indeed such monitoring (together with a disconnect alarm in ventilated patients) is an essential part of safe anaesthetic practice and should be mandatory. However, these monitors are not sensitive to events distal to the machine and breathing system. Other methods of detecting hypoxia must therefore be considered. Alveolar concentrations of oxygen may be measured by mass spectrometry, but this is not practical: arterial blood gas analysis is invasive and intermittent and transcutaneous $P\mathrm{O}_2$ measurement is unreliable except in neonates. Pulse oximetry provides a simple noninvasive way of continuously measuring oxygen saturation, although caution is necessary since anaesthetists employ inspired oxygen concentrations of 30% or more and therefore a decreasing oxygen saturation is a late sign of impending disaster. However, at the present time there is no method superior to pulse oximetry to detect oxygen desaturation. It does not determine the cause nor diminish the necessity of constant vigilance and rapid response by well trained anaesthetists.

The medicolegal consequences of hypoxic disasters can be horrendous and substantial damages have been awarded by the courts against doctors and Health Authorities. It is against this background that the view is being increasingly expressed that the use of pulse oximetry should be essential throughout every anaesthetic[3,4] and logically provided not only in the operating room but also in the anaesthetic and the recovery rooms.

The cost of implementation of this policy is not insignificant. Health Authorities and other colleagues will inevitably resist such a large capital expenditure but they need to be reminded of the consequences of mishaps. For several years in most Districts as little as 10% of such financial allocations is spent in the acute sector: a shift of capital to acute services is long overdue.

It is clear that anaesthetists as a group need to state clearly what they regard as minimum standards of monitoring in modern anaesthetic practice.

This is the most urgent task facing the specialty. It will then be the responsibility of Health Authorities to provide them and the responsibility of the doctor to use them appropriately and wisely.

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References

1. LUNN JN, MUSHIN WW. *Mortality associated with anaesthesia.* Oxford: Nuffield Provincial Hospital Trust, 1982.
2. *Confidential enquiry into perioperative deaths.* Nuffield Provincial Hospitals Trust, 1988.
3. MATHIAS JA, LUNN JN. Minimal monitoring and vigilance. *Anaesthesia* 1987; **42:** 683–4.
4. SYKES MK. Essential monitoring. *British Journal of Anaesthesia* 1987; **59:** 901–12.

Pulse oximetry for all?

Is there currently a cult following for pulse oximetry? Should every anaesthetic room, theatre and intensive care bay have a pulse oximeter? Should they become a standard part of our minimum monitoring package? These are questions currently being asked.

Dr Zorab highlights[1] the usefulness of pulse oximetry, and its value as a useful anaesthetic and intensive care monitor has already been recognised in some countries. Some medical malpractice insurance companies for example in North America will offer significant reductions in premiums if the anaesthetist undertakes to use one for every case. But is the usefulness and the reliability of the pulse oximeter being over stressed?

It was interesting to read Dr Ridley's article (*Anaesthesia* 1988; **43:** 136–40) which compared two oximeters, the Ohmeda Biox 3700 and the Nellcor N100E with the Radiometer OSM–2 oximeter. The accuracy of both oximeters was poorer than the manufacturers' claims. However they did follow the change in the saturation ($Sa\text{O}_2$) correctly.

Recently whilst monitoring a child with a Novametrix Model 500, the $Sa\text{O}_2$ (94%) appeared higher than would be expected for the arterial $P\text{O}_2$. The probe, attached to the toe of a 14-kg child, was left in the same position and simply plugged into another identical Novametrix Model 500, set up to sample in exactly the same manner. This second machine recorded a saturation of 88%, a 6% difference and a figure representing significant hypoxaemia. This manoeuvre was repeated at least six times and on each occasion the first oximeter read 94% and the second 88%. The manufacturers claim an accuracy of ±2% in the saturation range of 80–100%. Unfortunately we did not have a radiometer co-oximeter at our disposal to obtain a definitive $Sa\text{O}_2$. Here, and in other instances, we have clear evidence of oximeters failing to give accurate information, whilst they appear to function correctly. Unfortunately pulse oximeters cannot be calibrated at the bed side to check their accuracy.

With over 15 firms manufacturing pulse oximeters the industry must feel that there is a very large market. The number of models available has grown with great speed, and we have good reason to believe that not all these machines achieve the manufacturers' claims. Careful consideration should be given to those available before deciding which to buy.

We are not trying to decry the usefulness of pulse oximetry, but would like to draw attention to the fact that like all monitoring devices they are not infallible. Understanding the potential sources of error can only enhance patient care. There undoubtedly is a place in anaesthesia and intensive care for patient monitoring with pulse oximeters, but whether they should become a part of minimum monitoring standards remains to be seen. We would like to stress that, whatever may become mandatory minimum monitoring equipment, monitors are an adjunct to and do not replace the watchfulness of the anaesthetist. No amount of monitoring makes the unsafe safe. Close contact between the anaesthetist and patient still remains the backbone of safe anaesthesia.

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Reference

1. ZORAB JSM. Who needs pulse oximetry? *British Medical Journal* 1988; **296:** 658–9.

Assistance for anaesthetists

The President addressed in his Editorial (*Anaesthesia* 1987; **42:** 1043–4) the problem of recruiting nurses and the lack of trained (nurse-)assistance for the anaesthetist. One major aspect in this context is the lack of pupil nurses' knowledge about anaesthesia. Their mental conception of anaesthesia and the anaesthetist is formed during their stage on the surgical side of the operating theatre. A few lectures related to anaesthesia during a 3-year training course are hardly enough to have a longer lasting effect and to make a career in anaesthesia enticing. In order to lessen this problem we organised during the last year a one-week attachment to the anaesthetic department for the third year of their training. This gives the nurse-to-be a better understanding of the care of the patient undergoing anaesthesia and in the recovery room as well as information about the anaesthetic equipment and its maintenance. Some nurses even gain confidence in their ability to hold a face mask and ventilate a patient under expert instruction, which might prove useful even on general wards. We believe that the combination of a lecture series and a clinical attachment period will improve the chances to recruit nurses for anaesthesia and intensive care.

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Defects in epidural catheters

This is a report of a problem, encountered twice recently, with threading Tuohy needles over epidural catheters. On both occasions the epidural catheters came from an Everett Epidural Block Procedure Pack (Avon Medicals).

The first case was a male aged 72 years who presented for a total hip replacement. The epidural catheter was flushed with saline and the lumen and three side ports were confirmed to be patent. The epidural space was identified (at 5 cm from the skin) and the epidural catheter was introduced into the Tuohy needle and 15 cm were easily threaded through it. The needle was then withdrawn over the catheter and easily removed from the patient's back. However, when the hub of the needle had been withdrawn to a distance of about 30 cm from the tip of the catheter in the epidural space the Tuohy needle stuck, and it was not possible to pull it further along the catheter. Thus although the catheter was correctly placed in the epidural space the Tuohy needle was jammed on the catheter a short distance from the patient's back. It was not possible to leave the Tuohy needle there as the patient would have had to lie on it for the duration of the operation. It was decided to give a single shot epidural block through the catheter and remove catheter and needle simultaneously, and the operation then proceeded uneventfully. On closer inspection the catheter wall had a bulge which increased the outside diameter at 25 cm from the tip. It was not possible to thread this thickened portion through the 16-G Tuohy needle.

The second case was an obstetric patient who requested an epidural block for analgesia. The catheter was flushed easily with saline and the lumen and three side ports were confirmed to be patent. The catheter was threaded through the Tuohy needle after identification of the epidural space. Resistance to threading the catheter was felt when about 12 cm had passed into the needle. It was not possible to withdraw the needle from the patient's back without pulling the catheter out too, and since the tip of the catheter was 2 cm beyond the tip of the needle it was unwise to withdraw the catheter through the needle: the needle and catheter were withdrawn together. Inspection of the epidural catheter showed a similar bulge in the catheter wall at approximately 12 cm from the catheter tip, such that it would not thread through the 16-G Tuohy.

Both catheters had been tested for patency prior to insertion and appeared to be free from faults. It was only on close inspection after difficulty was encountered that the fault was identified. This problem has not been reported before. Close inspection of the whole length of the catheter and a test of its easy passage through the Tuohy needle is important before insertion is attempted.

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A reply

Our examinations confirmed these findings of bulges in the catheters, one of which could pass through the Tuohy, whilst the other could not. These bulges reflect isolated variations in the extrusion operation which were not identified during subsequent manufacturing and inspection operations.

We have modified our inspection procedures by the introduction of a test on each catheter during manufacture as a result of your report. It eliminates any chance of a future occurrence of this nature.

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A single dose epidural technique for Caesarean section

The article by R.S. Laishley and B.M. Morgan (*Anaesthesia* 1988; **43:** 100–3) advocates the technique of a single injection of 20 ml 0.5% bupivacaine plain or with adrenaline through a Tuohy needle. It is in my personal experience possible to have a false loss of resistance and to inject at least 10 ml solution without problem. Thus it is possible to have injected 20 ml 0.5% bupivacaine superficially and be unable to repeat the epidural safely because of the limitation of the maximum safe dose of bupivacaine. The authors subsequently insert an epidural catheter, but I consider it to be safer, as a precautionary manoeuvre, to ensure that the epidural space has indeed been reached, to insert and then inject first through the epidural catheter, rather than through the Tuohy needle.

The evidence that direct injection through the Tuohy needle enhances the effects of epidural analgesia, is limited and unproven.[1] Furthermore, in their study the mean total volume of 0.5% bupivacaine plain or with adrenaline was 24 and 21 ml respectively, and the requirement for supplementary opiates or nitrous oxide was 20%. These results are no better than in other studies on epidural Caesarean sections,[2,3] and thus do not support their technique.

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References

1. MEHTA P, THERIOT E, MEHROTRA D, PATEL K, MEHTA D, TAHVILDARI F, ZARBALIAN A. Technique of injection, maternal position and spread of anaesthetic in epidural anesthesia. *Anesthesiology* 1983; **59:** A410.
2. THORNBURN J, MOIR DD. Epidural analgesia for elective section. Technique and its assessment. *Anaesthesia* 1980; **35:** 3–6.
3. JAMES FM, CRAWFORD JS, HOPKINSON R, DAVIES P, NAIEM H. A comparison of general anesthesia and epidural analgesia for elective cesarean section. *Anesthesia and Analgesia* 1977; **56:** 228–35.

A reply

We thank Dr Ratcliffe for interest in our article.

Certainly it is mandatory for any drug to be injected into the place for which it is intended and the use of local anaesthetics requires meticulous attention to technique if toxicity is to be kept to a minimum. Inadvertent intravenous injection of bupivacaine may result in convulsions and cardiac arrest.[1] The bore of the Tuohy needle is wider than that of epidural catheters so its accidental intravenous placement is less likely to remain unrevealed, even after aspiration. Injection of bupivacaine down the epidural catheter is for this reason regarded as less safe than injection through the Tuohy.

Eighty-five percent of the mothers in the adrenaline group received only 100 mg of bupivacaine and 65% in the plain group. The mean bupivacaine dose in the adrenaline group was 107.5 mg and in the plain group 121.25 mg. Ten percent of women in the adrenaline group required supplementary systemic analgesia compared with 30% in the plain group.

We therefore conclude that the advantages of the technique described is an induction to incision time of 20 minutes, a low overall dose of local anaesthetic and a more effective block if adrenaline is used with the bupivacaine.

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Reference

1. ALBRIGHT GA. Cardiac arrest following regional anesthesia with etidocaine or bupivacaine. *Anesthesiology* 1979; **51:** 285–7.

Epidural opioids for labour

The administration of epidural opioids to women in labour was described by Justin and co-workers.[1] They observed that fentanyl, in combination with low dose bupivacaine was beneficial in the relief of persistent perineal pain. This report is of a mother suffering from severe pre-eclampsia in whom epidural fentanyl was particularly helpful. It provided good analgesia in a patient whose agitation made monitoring impossible.

A 22-year-old primiparous patient, height 166 cm, weight 99 kg, presented at 34 weeks' gestation with an arterial blood pressure of 180/120 mmHg, marked proteinuria and oedema; she had experienced epigastric pain of 3 days' duration. The cervix was 4-cm dilated and labour was induced. The coagulation screen was normal. Chlormethiazole 220 ml was administered intravenously over 90 minutes before a request was made for epidural analgesia. Maternal disorientation and agitation, in addition to obesity, made the management and monitoring of labour difficult. The epidural catheter was sited at the second lumbar interspace with some difficulty.

Ten millilitres 0.25% bupivacaine appeared to provide some analgesia though assessment of block was impossible. An infusion of bupivacaine 0.1% 10 ml per hour, was started; blood pressure was controlled by an intravenous labetolol infusion. Chlormethiazole was discontinued after a further 440 ml were infused over 60 minutes since the mother remained confused and was receiving an excessive fluid load. It was considered that her confusion might be a manifestation of preconvulsive cerebral irritation, so she was given diazepam and phenytoin intravenously.

She became more coherent, and complained of perineal pain and rectal pressure unrelieved by further bupivacaine. Fentanyl 100 μg in 10 ml sodium chloride administered epidurally provided complete analgesia within 10 minutes. The mother was able to lie comfortably in bed, cooperated with the staff and allowed herself and the fetus to be monitored. Eighty-five minutes later she delivered a 1.61 kg male infant by mid cavity forceps; Apgar scores were 6 at 1 minute, 8 at 5, and 9 at 10 minutes.

The administration of sedative drugs to patients in pain is liable to worsen agitation. This woman's confusion and distress prevented the recognition of the inadequacy of her epidural block. Cessation of chlormethiazole enabled better communication. The administration of epidural opioids dramatically relieved perineal pain resistent to bupivacaine and may be the agent of choice in deficient epidural block.

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Reference

1. Justins DM, Francis D, Houlton PG, Reynolds F. A controlled trial of extradural fentanyl in labour. *British Journal of Anaesthesia* 1982; **54:** 409–14.

Is pyrexia a contraindication to epidural blood patch?

The incidence of postpartum pyrexia is 1–3% and falling.[1] Appropriate investigations should be instituted if a single temperature increase of greater than 38°C or any sustained pyrexia for longer than 24 hours occurs. Pyrexia may be associated with life threatening infection (puerperal sepsis accounted for 4.6% of all maternal deaths in the 1979–81[2]), alternatively it may be of no significance.[3]

A 26-year-old primagravida with a postdural puncture headache developed a fluctuating pyrexia with peaks up to 38°C for 5 days after delivery. She remained well clinically; appropriate investigations including blood cultures were negative, and her temperature resolved spontaneously without specific treatment. A successful epidural blood patch was performed when she became apyrexial.

Should this patient have had an epidural blood patch earlier to relieve her severe headache? In view of the complications of the injection of infected blood into the epidural space we considered that a delay until she became apyrexial was the safest option. Discussion with colleagues reveals that management of these cases is controversial and ranges from blood patch irrespective of temperature if the patient is clinically well, to complete avoidance of this method of treatment in these circumstances.

We would welcome other peoples' opinions and policy guidance on this matter.

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References

1. Llewellyn-Jones D. *The complicated puerperium in fundamentals of obstetrics and gynaecology.* Vol. 1, 4th edn. London: Foster and Foster, 1986: 383–92.
2. *Report of confidential enquiries into maternal deaths in England and Wales 1979–81.* London: Her Majesty's Stationery Office London, 1986.
3. Clayton SG, Lewis TLT, Pinker GD. *Puerperal pyrexia in obstetrics by ten obstetricians.* 13th edn. London: Edward Arnold, 1986: 414–21.

Acute inversion of the uterus

Drs Emmott and Bennett (*Anaesthesia* 1988; **43:** 118–20) report two cases of uterine inversion at Caesarean section. They postulate that epidural blockade would be expected to obtund the afferent pathways that cause hypotension secondary to peritoneal and broad ligament stretching and ovarian compression associated with uterine inversion at Caesarean section, and prevent the hypotensive response during inversion.

This is a report of acute uterine inversion at Caesarean section, under epidural analgesia, where acute hypotension was associated with inversion which was reversed on uterine reversion.

A healthy, 38-year-old-woman (gravida 3, para 0), on thyroxine after partial thyroidectomy, presented at 39 weeks' gestation for elective Caesarean section, because of breech position of the fetus. Epidural analgesia was requested for fetal, maternal and paternal reasons and was instituted, after crystalloid preloading of the circulation, with an incremental dose method, using 24 ml 0.5% plain bupivacaine. Arterial blood pressure and pulse rate were maintained at 125/75 mmHg and 70–80 beats/minute with further crystalloid and 10 mg of ephedrine. A live male infant was delivered by lower segment Caesarean section.

The placenta failed to separate after delivery. Synthetic oxytocin 10 units was given, the uterus contracted well and the placenta appeared to be delivering spontaneously. No cord traction was used. Examination showed a firmly adherent placenta (as in case 2) and uterine inversion. A period of 35 minutes elapsed before placental separation and uterine reversion was achieved. For 15 minutes (similar to case 1) arterial blood pressure and pulse remained stable. There was a period of hypotension after this with a minimum systolic pressure of 45 mmHg. Arterial blood pressure was restored with rapid infusion of 1000 ml Hartmann's, 500 ml polygeline solutions and 20 mg ephedrine administered intravenously in divided doses. Droperidol 0.5 mg was given for mild maternal nausea. No further oxytocic was given. An increased $F\text{IO}_2$ was administered throughout the procedure. Blood loss was estimated to be more than 1000 ml and a 2-unit blood transfusion was started. Arterial blood pressure returned to normal after uterine reversion and surgery was completed uneventfully. No post partum sequelae occurred. The presence of the neonate and husband proved of great benefit as maternal distractors.

This case reinforces the findings in the literature that inversion occurs after delivery of the infant, before that of the placenta and that it occurs immediately after administration of a synthetic oxytocic. Hypotension was out of

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proportion to the blood loss, and this cannot be explained by reflex mechanisms which were presumably blocked by the epidural analgesia. Epidural analgesia may have exacerbated the effect of the blood loss but this was countered by rapid infusion of fluid and ephedrine administration. Part of the hypotension could perhaps be accounted for by vasovagal influences. These influences might take effect as the enormity of the situation began to be perceived by the mother despite reassurances from anaesthetist, obstetrician and husband. This could explain the absence of a tachycardic response and the mild maternal nausea seen in this case and the second case of Emmott and Bennett.

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A reply

Thank you for the opportunity to reply. We observed that, at uterine inversion during Caesarean section haemodynamic instability was out of proportion to the degree of blood loss, and on this basis suggested that effects secondary to broad ligament and peritoneal stretching and ovarian compression may act as hypotensive influences. We further supposed that epidural blockade would prevent these effects by obtunding visceral afferent autonomic pathways at spinal level. Hypotension did happen in the case reported by Dr Broadway in the presence of epidural blockade, but we would still not dismiss the possibility that epidural anaesthesia may be protective in this rare condition. Epidural block even up to T_{4-5} level may still be associated with discomfort on surgical stimulation of the upper abdominal peritoneum, a phenomenon presumably mediated by unblocked sympathetic fibres deriving from upper thoracic levels, and also possibly via vagal afferents unaffected by epidural block. Gradual recovery of upper thoracic sympathetic fibres may thus explain a delayed onset of hypotension during an otherwise satisfactory epidural block. Vagal effects may account for the absence of tachycardia, but should not occur because of broad ligament stretching or ovarian compression since these structures are not, to our knowledge, supplied by the vagus nerve. Partial block of cardiac sympathetic fibres might also explain the lack of tachycardia, and would theoretically blunt the reflex sympathetic response to hypovolaemia.

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A. BENNETT

Laryngospasm due to incomplete reversal not angina

The suggestion that acute angina can precipitate postoperative laryngospasm by Drs Lyew and Bissett (*Anaesthesia* 1988; **43:** 60–1) was interesting; however, incomplete reversal of neuromuscular blockade is a more likely explanation for the laryngospasm observed in their patient. Five of my patients with similar postoperative laryngospasm which responded to sedation also had mild residual neuromuscular block but none showed any evidence of ischaemic heart disease.

All five patients had general tracheal anaesthesia with either atracurium or vecuronium to provide relaxation and shared a similar clinical course. There was some doubt at the end of the procedure as to whether complete reversal of the neuromuscular block was feasible but, following the administration of atropine and neostigmine, the patients had breathed well and their tracheas were extubated uneventfully. All patients awoke rapidly, were talking, and able to lift their head off the pillow. Each patient complained of difficulty with breathing, within 3 to 10 minutes after regaining consciousness despite apparent good tidal volumes and, at the same time, developed inspiratory laryngeal stridor. This stridor rapidly worsened with mounting anxiety and, if not treated promptly, progressed to almost complete airway obstruction. Resedation using intravenous diazepam or, in one case, 50% nitrous oxide invariably relieved the stridor. One patient initially received additional neostigmine but this only caused a slight improvement. Peripheral nerve stimulation after resedation demonstrated post-tetanic facilitation in all cases. Other causes of laryngospasm such as inhaled foreign body or laryngeal oedema did not appear to be implicated since the stridor did not recur once neuromuscular recovery was complete.

This manifestation of residual neuromuscular blockade is, I assume, the pharmacological equivalent of bilateral partial recurrent laryngeal nerve palsy, where the muscles adducting the vocal cords predominate over the abductors, with resultant laryngeal obstruction. Oddly, laryngospasm does not seem to occur in patients who have been pretreated with competitive relaxants before the induction of anaesthesia, even when a relative overdose has been given. This may be because laryngeal irritation from intubation is also required to initiate the vicious circle of progressive spasm and anxiety. The various competitive relaxants do not share the same relative potencies when comparing their effects on fast muscle fibres with those on slow muscle fibres.[1] This might explain why the observed imbalance of laryngeal muscle activity does not seem to occur with all competitive relaxants. Presumably sedation is effective in treating the stridor since it abolishes the anxiety and hence reduces laryngeal tone.

Whatever the cause of this syndrome, it is vital that it is recognised since it occurs when the anaesthetist is likely to be preoccupied with inducing anaesthesia in another patient.

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Reference

1. DAY NS, BLAKE GJ, STANDAERT FG, DRETCHER KL. Characterization of the train-of-four response in fast and slow muscles: effect of d-tubocurarine, pancuronium, and vecuronium. *Anesthesiology* 1983; **58:** 414–17.

Prolonged femoral nerve block with 0.5% bupivacaine

A 54-kg, 51-year-old, female patient was given, in error, 0.5% instead of 0.25% bupivacaine, for a 3-in-1 lumbar plexus block.[1] The volume of local anaesthetic used was 36 ml, so that the dose was 180 mg or 3.3 mg/kg.

Venous blood samples were taken at 5, 10, 20, 30, 45 and 60 minutes after injection, as part of a study of 3-in-1 block.[2] Plasma was stored at −20°C and the bupivacaine concentration was measured using high performance liquid chromatography (HPLC). The peak concentration was 0.92 μg/ml and occurred at 45 minutes. This is well below the threshold for CNS toxicity in man which ranges from 2–4 μg/ml for bupivacaine.[3] The patient did not experience any systemic side effects.

Complete femoral nerve block, which involved the saphenous, medial anterior and intermediate anterior cutaneous nerves of the thigh with loss of knee extension, developed 10 minutes after injection. This persisted for over 30 hours. There was patchy sensory loss on the thigh at 48 hours, but at this stage she was able to stand and walk slowly with support. The leg did not feel subjectively normal for 72 hours. Discharge from hospital was delayed for 24 hours and the patient suffered considerable distress.

This case emphasises that 0.5% bupivacaine is an inappropriate concentration for local anaesthesia for minor procedures of the lower limb, after which the patient could be mobilised within 24 hours. Injection of local anaesthetic into the fibrous sheath around the femoral nerve results in a very low rate of systemic absorption.[4] There was no evidence of block of either lateral cutaneous nerve of thigh or obturator nerve block.

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References

1. Winnie AP, Ramamurthy S, Durrani Z. The inguinal paravascular technic of lumbar plexus anesthesia: the '3 in 1' block. *Anesthesia and Analgesia* 1973; **52:** 989–96.
2. Madej TH, Ellis FR, Halsall PJ. An evaluation of '3 in 1' block in patients having muscle biopsy. In preparation.
3. Tucker GT, Mather LE. Clinical pharmacokinetics of local anaesthetics. *Clinical Pharmacokinetics* 1979; **4:** 241–78.
4. Moore DC, Mather LE, Bridenbaugh LD, Balfour RI, Lysons DF, Horton WG. Arterial and venous plasma levels of bupivacaine following peripheral nerve blocks. *Anesthesia and Analgesia* 1976; **55:** 763–8.

Carbon dioxide laser surgery

The use of the laser beam in the airway causes a new problem for the anaesthetist: how can ventilation of the lungs be maintained adequately without interference with access for the surgeon and without fire? Drs Hunton and Oswal (*Anaesthesia* 1987: **42:** 1222–5) describe, in an interesting article, their method of anaesthesia combined with spontaneous ventilation in 33 patients. They mention a number of difficulties: tracheal intubation is performed twice, a high flow of oxygen and nitrous oxide with halothane, continuous positive airway pressure, increased $P\text{aco}_2$, breakdown products of halothane, the impossibility of the use of opioids during anaesthesia, and the high concentration of oxygen administered during laser treatment.

Intravenous anaesthesia in combination with high frequency ventilation (HFV) might be an adequate solution for laser treatment in the airway. The other lung may be ventilated when HFV is used during treatment of a bronchial lesion. Oxygen enriched air may be employed without volatile anaesthetics so that there is no pollution of the operating room with anaesthetic gases or vapours. Short acting drugs may be utilized for intravenous anaesthesia.

We use methohexitone together with alfentanil for induction of anaesthesia and in a drip infusion during the surgical procedure.[1] Methohexitone 500 mg and alfentanil 5 mg are added to glucose/saline 250 ml and an infusion pump is used, started usually with 200 ml/hour for 10 minutes, and then the infusion rate is halved. A second infusion contains a 0.1% solution of suxamethonium, usually at 80–100 drops/minute.

For HFV the Acutronic MK 800 apparatus (Acutronic Medical Systems, Jona–Rapperswil, Switzerland) is used at a frequency of 100 cycles/minute, oxygen enriched air (up to $F\text{io}_2$ 0.5), an inspiration time of 30% and a working pressure of 1.3 to 1.8 bar. For tracheal intubation and ventilation an insufflation (oxygen) catheter FG 14 (Airlife Inc., Montclair, CA 91763) is used covered with aluminium foil.[2] A convenient thin metal tube is not yet available. The thin insufflation catheter allows a free view onto the glottic region when the suspension laryngoscope or the rigid bronchoscope are used during laser surgery. Smoke is continuously extracted. In very difficult situations with obtruding tumours in the larynx, percutaneous transtracheal HFV is used.

This anaesthetic procedure was carried out in more than 300 patients during laser treatment in the upper airway. Blood gas analyses, peripheral $S\text{ao}_2$, rate pressure product were satisfactory. There was no awareness.

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C. Mallios

References

1. Scheck PA, Mallios C, Peroral endoscopies using intravenous anesthesia and high frequency ventilation. *Critical Care Medicine* 1984; **12:** 803–5.
2. Scheck PA, Mallios C, Knegt P, Van de Schans EJ. High frequency ventilation in laser surgery of the larynx. *Clinical otolaryngology* 1984; **9:** 203–7.
3. Hunton J, Oswal VH. Metal tube anaesthesia for ear, nose and throat carbon dioxide laser surgery. *Anaesthesia* 1985; **40:** 1210–12.

A reply

We accept that the use of high frequency ventilation is one solution for laser treatment in the airway. This has been reported by several workers as we discussed. It is stated that we listed 'problems' and tracheal intubation is performed twice. In fact, tracheal intubation is performed on all patients before insertion of the bronchoscope. However, anaesthesia was maintained through the bronchoscope during the laser procedure in all cases.

The high flow of oxygen and nitrous oxide we found to be an asset not a disadvantage because it improves the smoke clearance but this technique certainly does increase pollution. We agree that it is inadvisable to administer opioids during this form of anaesthesia but we find that the analgesic requirements for patients who undergo laser surgery to the trachea main bronchi are small.

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Bradycardia during elevation of zygomatic fractures

The recent case report by Drs Shearer and Wenstone (*Anaesthesia* 1987; **42:** 1207–8) was interesting. There was a similar response during elevation of a fractured malar in a healthy 27-year-old man whom I anaesthetised recently. The heart rate decreased abruptly from 65/minute to less than 30/minute; this was followed by a period of sinus arrest which responded quickly to atropine 0.6 mg and resulted in a heart rate of 85/minute with multiple ventricular ectopics. The heart rate decreased abruptly to 60/minute during subsequent attempts at elevation of the fracture. Anaesthesia and surgery proceeded uneventfully thereafter.

This reflex bradycardia was described previously by Robideaux[1] and, more recently, by Bainton[2] who recommended that atropine or glycopyrronium be given at induction to prevent its occurrence. Personal communication from my colleagues suggests that reflex bradycardia is not uncommon during elevation of zygomatic fractures, and I now routinely pretreat with glycopyrronium.

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A reply

We thank Dr Gillespie for his interest in our article and are pleased to hear that he confirms our belief that a reflex bradycardia is not uncommon during elevation of zygomatic fractures. We also agree with his recommendation for anticholinergic pretreatment of these patients, and indeed, that is our usual practice.

However, we disagree with his assertion that the reflex was previously described by Robideaux[1] whose report concerned a fracture of the floor of the orbit. Disimpaction of this fracture placed traction upon the intra-orbital contents, which one would expect to produce a classical oculocardiac reflex. Our report concerned reflex bradycardia caused when the orbit and its contents were undisturbed. Presumably, the reflex we describe is therefore mediated through an alternative pathway.

We were interested to read the subsequent report by Bainton and Lizi.[2] We are pleased that oral surgeons themselves are becoming aware of this potentially dangerous reflex. One would hope that they would become as concerned with its detection and prevention as are their ophthalmic colleagues with the classical oculocardiac reflex.

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E.S. Shearer

References

1. Robideaux V. Oculocardiac reflex caused by midface disimpaction. *Anaesthesiology* 1978; **49:** 433.
2. Bainton R, Lizi E. Cardiac asystole complicating zygomatic arch fracture. *Oral Surgery, Oral Medicine, Oral Pathology* 1987; **64:** 24–5.

Retrograde intubation

We report a technique for retrograde intubation which varies from the commonly used one of Harmer and Vaughan.[1]

Our technique is a modification of the one described by Powell and Odzil[2] and has been successfully used in 10 patients who have either been difficult intubations (for a variety of reasons). or who have had unstable cervical spine fractures which required surgical fixation. The skin over the cricothyroid membrane is anaesthetised using subcutaneous infiltration of lignocaine 1%. Lignocaine 2% 2 ml is then injected percutaneously into the trachea through the cricothyroid membrane, the pharynx sprayed with 4% lignocaine, and a small incision made in the skin above the cricoid cartilage. A 16-gauge Tuohy needle is passed through the cricothyroid membrane into the trachea and aimed in a cephalad direction; the correct position of the Tuohy needle in the trachea is confirmed by the aspiration of air into a syringe. A nylon thread (Ethilon Blue W749) is then passed through the epidural needle into the pharynx; the patient either spits this out of his mouth or if necessary it is removed from the pharynx using a laryngoscope and Magill's forceps. The nylon thread is sewn through the tip of a well-lubricated tracheal tube using a curved, round-bodied size 3 Mayo needle. The thread is knotted to the tip of the tube in the middle of its length, which allows one end of the thread to protude from the patient's mouth when the tracheal tube is in place. Both ends of the thread are clipped with artery forceps for security. The armoured tube is gently introduced through the patient's mouth, initially into the oesophagus. It is then slowly withdrawn from the oesophagus whilst breath sounds are listened for. As soon as they are well heard, the distal end of the nylon thread is pulled and the tube enters the trachea. The thread is not pulled tight before this stage so as to avoid a possible cheesewire effect.

A commonly encountered problem with retrograde intubation is that the tube is held up at the epiglottis. Harmer and Vaughan overcome this difficulty by passing a stiffened suction catheter over the epidural catheter. In our technique this problem is overcome at first by passing the tracheal tube into the oesophagus. Also, the passage of the tip of the tracheal tube in our technique can be controlled by manipulation of the two ends of the thread. In the Harmer and Vaughan technique the epidural catheter is cut off at the skin entry site and removed from above in order to allow the tracheal tube to enter the trachea. The epidural catheter has to be reinserted if the tracheal tube fails to enter the trachea, and the whole procedure repeated. The great advantage of this technique is that even after the patient has been extubated the nylon thread can be left in place and used again should the patient require reintubation. This is of particular advantage if the nature of the surgery, for example the transoral approach to the odontoid peg, may produce postoperative oedema in any part of the airway. Fortunately, reintubation of our patients has never been necessary. To date, we have had no failures and no complications using this technique for retrograde intubation.

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C.A. Harrison
C.C. Wise

References

1. Harmer M, Vaughan RS. Guided blind oral intubation. *Anaesthesia* 1980; **35:** 921.
2. Powell WF, Odzil T. A translaryngeal guide for tracheal intubation. *Anesthesia and Analgesia* 1967; **46:** 231–4.

The technique described in the case report by Drs Cooper and Murray-Wilson (*Anaesthesia* 1987; **42:** 1197–1200) was previously called guided blind intubation.[1,2] Retrograde intubation is a misnomer. The guide wire or catheter is threaded in a retrograde manner, but the tracheal tube is passed in the normal direction.

More important than this semantic quibble is the fact that, after various attempts at tracheal intubation had failed, the crucial manoeuvre was the 90° anticlockwise twist of the tube, to facilitate rail-roading the tube along the guide, into the trachea. This rotation causes the tip of the tube to lie anterior to the guide, in close contact with it. There is often a gap between the guide and the tip of the tube if a tracheal tube is rail-roaded over a guide. Thus, the tip of the tube may catch on the right vocal cord or behind the arytenoids, and prevent its further progress. In the past, I suggested[3] that the anticlockwise twist would help, and I am pleased to learn from the case report that it did.

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P.S. Cossham

References

1. Akinyemi OO, John A. A complication of guided blind intubation. *Anaesthesia* 1974; **29:** 733–5.
2. Waters DJ. Guided blind endotracheal intubation for patients with deformities of the upper jaw. *Anaesthesia* 1963; **18:** 158–62.
3. Cossham PS. Difficult intubation. *British Journal of Anaesthesia* 1985; **57:** 239.

Heat and moisture exchangers and closed systems

The end tidal CO_2 was noted to be rising gradually during a recent anaesthetic and after 20 minutes of spontaneous ventilation had reached 9%. There was no clinical respiratory depression or obstruction; the absorber was switched on; the inspired oxygen concentration of the fresh gas flow of 1 litre/minute and patient's oxygen saturation were normal. The inspired concentration of CO_2 became raised and the indicator in the sodalime did not change colour. A further check of the system revealed that a condenser–humidifer (Humivent) had been inadvertently connected to the catheter mount. This was removed, but no other adjustment was made. Five minutes later the end tidal CO_2 had decreased to 5%, there was no CO_2 in the inspired gas and the indicator was changing colour.

Presumably the sodalime, which was new, was completely dry, and the condenser–humidifier was preventing moisture from reaching it. Water is needed to initiate the absorption reaction of CO_2 by sodalime, so the removal of the condenser–humidifer would have allowed the reaction to proceed.

Normally, a condenser–humidifier would not be fitted to a circle system because the circle itself conserves both heat and moisture. Consequently, it is unnecessary to fit a condenser–humidifier and in the light of this case, is potentially hazardous!

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M. Bellamy

Modification of Goldman dental mask

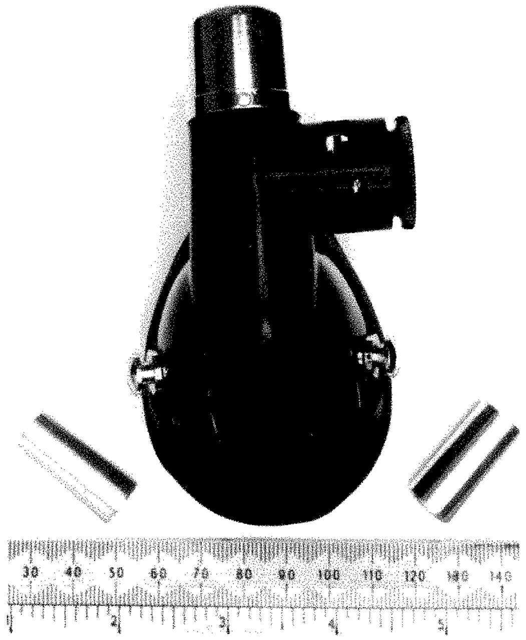

Fig. 1.

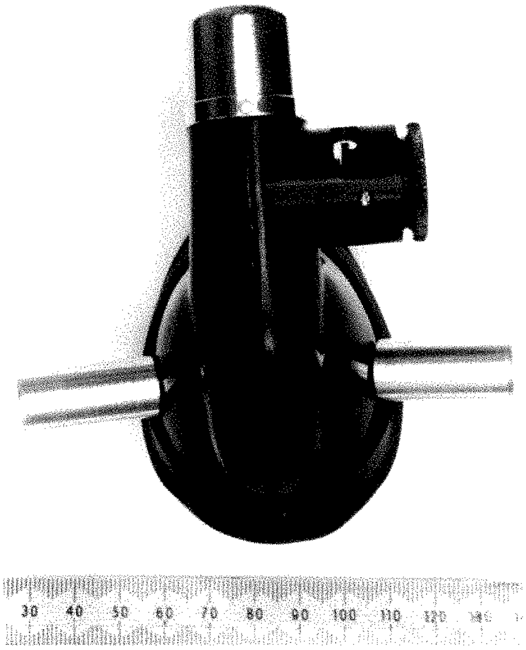

Fig. 2.

The widebore Goldman nosepiece for the administration of dental anaesthesia from a continuous flow apparatus is provided with two studs for the attachment of a harness.

The harness is inconvenient to use for short procedures and I have found that two pieces of 12.7 mm (½ inch) diameter of Duralumin rod suitably drilled can be attached to the studs. These facilitate the application of the mask by the thumbs whilst the fingers are free to maintain the airway by supporting the angles of the jaw, (Figs 1 and 2). The Duralumin may have some advantages in terms of durability and ease of sterilisation over the dental acrylic modification previously described.[1]

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S.K. Anderson

Reference

1. Bowman RA. A modification to Goldman ental nasal mask. *Anaesthesia* 1978; **33:** 844–5.

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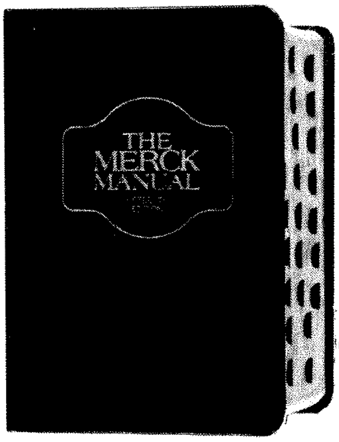

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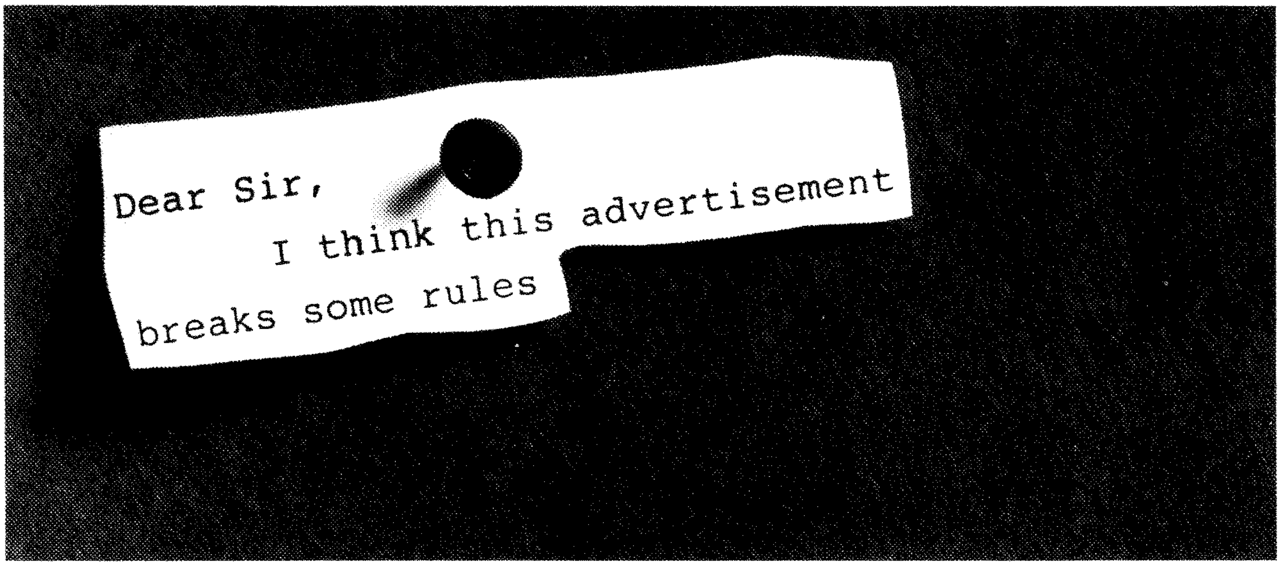

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Anaesthesia for porphyria using propofol

A 54-year-old female, who had acute intermittent porphyria diagnosed 18 years previously, presented for manipulation of a Colles' fracture. She was very anxious about anaesthesia, but insisted that she wanted to be asleep for the procedure.

An intravenous anaesthetic technique was used. Fentanyl 100 μg was given, followed by propofol in incremental doses. Oxygen 100% was administered via a Magill system: ventilation was assisted manually at times. The procedure lasted 25 minutes, and a total of 400 mg propofol was used. Recovery was smooth and quick, within 12 minutes of stopping propofol. The patient had no recall of events during anaesthesia. Close observations postoperatively did not elicit any colicy abdominal pains, paralysis, psychosis, or altered urine colour.

This single case suggests that propofol can be used safely in patients with porphyria.

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R. COOPER

A modified airway

We report a case where the use of a modified airway helped to make a difficult tracheal intubation much easier.

The patient was a fit 19-year-old man who had been starved for 6 hours. He had a broken nose which caused his nasal septum to be deviated to the right. There were bilateral septal haematomata which needed drainage. He had a receding jaw, large front teeth, and a difficult intubation was expected.

The first attempt to perform a gaseous induction failed because the patient clenched his teeth and caused airway obstruction. An airway could not be inserted. He was given 100% oxygen and woken up. A second attempt was made, after full explanation to the patient. The patient held, between his teeth, an airway which had been cut in half (Fig. 1). This prevented apposition of the teeth, and was easily exchanged for a full airway once sufficient depth of anaesthesia had been attained.

This modification of an airway is easily made, is not uncomfortable to the patient and does not provoke the gag reflex as a complete airway may. We hope it may prove useful in similar cases to avoid the problem of clenched teeth.

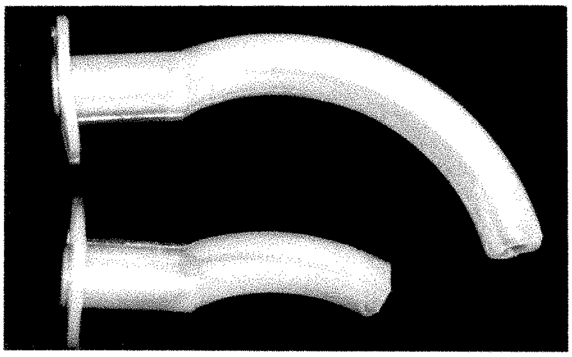

Fig. 1.

Royal Hallamshire Hospital,
Sheffield

A. CHAFFE
M.N. STREET

Prolonged recovery after propofol and diazepam

Propofol has become a very popular intravenous anaesthetic agent for daycase surgery because of its general properties of rapid induction and rapid recovery, but a combination of propofol and benzodiazepine can lead to prolonged recovery. Two young patients presented as daycases for flexible gastroscopy under sedation.

One (18 years) weighed 64 kg and another (22 years) weighed 77 kg; both were extremely nervous but were otherwise fit. They were given diazepam (as Diazemuls) 15 mg and 20 mg respectively, but as they were very nervous the surgeon found it difficult to pass the gastroscope, so they were given propofol 100 mg and 150 mg respectively. Both patients were asleep and the gastroscopy proceeded with no further problems. The procedure lasted about 10 minutes in each case, but the patients were not rousable for 3 to 4 hours. There was no response to painful stimuli and they were transferred to Day Care wards where they were closely monitored and given 40 percent oxygen. The patients were admitted overnight in case of further delayed reaction but were discharged the next day without further complications.

Does propofol prolong the effect of benzodiazepine, or *vice versa*; or has it an effect on the benzodiazepine receptors? Has anyone else encountered a similar problem, or studied the effect of this combination?

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M.K. GADEMSETTY

Unusual detection of an old problem

This is a report of a silent leak of gases from an anaesthetic machine which occurred in the anaesthetic room. A patient was brought from the operating room back to the anaesthetic room for ventilation of the lungs, while waiting for adequate time to pass before the reversal of a non-depolarising muscle relaxant. This was to allow the operating room to be used for an emergency operation.

A Manley Pulmovent ventilator was connected to the outlet of a King Boyle wall unit. The ventilator did not work. Another Pulmovent also did not function satisfactorily, but started as soon as the emergency oxygen flush button was pressed. A leak in the system was detected at the junction of the Rotameters with the vaporizer with the help of soapy water. This leak was obviously small since the reservoir bag of the Magill system could be filled, but too large to allow sufficient driving pressure for the ventilator, even though the flow rate through the Rotameters was 10 litres/minute.

The anaesthetic room is usually used for short periods, and in the absence of a pressure alarm or oxygen analyser it is obvious that a full 'cockpit drill' should be carried out. This leak would have remained undetected for a long time if the need for an automatic ventilator had not arisen.

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A.M. QADRI

Facilitation of wide bore cannula insertion

Peripheral placement of a wide bore cannula to provide a route for rapid intravascular volume replacement in the hypovolaemic and vasoconstricted patient can be difficult. Previous attempts with inappropriate narrow-bore cannulae and at prime sites compound these difficulties.

Forced distension of veins proximal to a correctly placed narrow-bore cannula (and distal to a limb tourniquet), is described as a means of providing a route for wide bore cannula insertion. This distension may be achieved by injection[1] or pressurised infusion of crystalloid solution through the narrow bore cannula. The technique is useful, but in practice it creates several problems of its own. The veins although distended are often difficult to see, and confirmation of successful venepuncture (by observing 'flashback' into the cannula hub) is similarly hampered by the colourless nature of the venous contents. Extravasation of large volumes of crystalloid, under pressure, should venepuncture not be followed by successful cannulation, is a more worrying complication.

Three simple refinements to the basic technique are possible. Addition of a small amount of *dye* (e.g. 0.5 ml of methylene blue in 500 ml) to the infusate, or the use of crossmatched blood (if available) to distend the veins. *Limitation of distending pressure* can be achieved either by using a sphygmomanometer cuff as the limb tourniquet or more simply by relying on the hydrostatic pressure generated by having the infusate bag higher than the patient's limb. In practice, inflation of the cuff to a pressure of 60–70 mmHg or elevation of the infusate bag to a height of one meter above the patient seems satisfactory. The infusate can be *warmed*. These extra tricks seem to help in my experience.

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J. McCrory

Reference

1. Gemmell L. Difficult intravenous cannulation: a solution. *Anaesthesia* 1984; **39:** 1251.

Concealed intra-arterial injection of thiopentone

We wish to draw attention to a case we encountered recently where signs (and possibly serious side effects) of intra-arterial injection of thiopentone were masked when a routine anaesthetic technique was used.

A 16-year-old healthy girl, ASA 1, was scheduled for elective removal of tonsils and adenoids. Despite usual premedication with oral temazepam (20 mg), she was still quite anxious on arrival in the anaesthetic room and had cold hands. A tourniquet was applied to the left forearm and a blue coloured vessel was seen on the dorsum of the hand in the third interosseous space. This dilated further with gentle tapping and a 23-G winged needle (intermittent) was easily inserted. No blood remained in the tubing after release of the tourniquet. Gentle aspiration through the needle confirmed its presence within a blood vessel. Initially, 2% lignocaine 4 ml was injected as a prophylaxis for suxamethonium afterpains. In the early stages of its injection, the patient complained of some discomfort in the region of the needle; a further check for blood by aspiration was positive and no extravasation was seen. Approximately 30 seconds later, injection of thiopentone (2.5%) was commenced. The patient complained of a heaviness of the hand and wrist and again aspiration showed the presence of blood. Two areas of blanching were noted over the dorsum of the wrist which disappeared when injection was temporarily stopped. The patient denied any unusual feelings in her fingers on direct questioning and examination showed them to be unchanged at this stage. The blanching reappeared on continuation of the injection, along with the heaviness. It was not a very unpleasant experience (certainly less than is seen with some other induction agents) and was assumed to be related to vasospasm exacerbated by the peripherally shutdown state. Normal induction of anaesthesia ensued and after administration of suxamethonium, the trachea was intubated and anaesthesia continued with 65% nitrous–oxide in oxygen with isoflurane 1–3% with spontaneous respiration via a Bain system.

The left hand was noted to be congested and blue in colour but a pulse oximeter on her left thumb showed a saturation of 98–99% after about 10 minutes of the operation. The hand felt warm, capillary filling was brisk and normal radial and ulnar arterial pulses were present. Closer inspection showed residual blood in the needle tubing to be pulsating and a pulsation could be felt in the vessel proximal to the tip of the needle. We therefore assumed the needle to be intra-arterial and after a sample was taken for blood gas analysis it was flushed through with saline (5 ml) and hydrocortisone (100 mg). A vasodilator was not administered since there was no evidence of vasospasm and lignocaine had already been given.

The colour of the hand gradually returned to normal and 20 minutes after operation both hands looked similar. The right hand was noted to have a similarly placed pulsatile vessel. The dorsum of the hand was tender and the arm was kept elevated after operation. The dorsum of the hand became swollen, painful and tender on the following day. The arm was maintained in elevation and lead and spirit dressings were applied and the swelling subsided over the next 48 hours, during which time an area of bruising appeared at the site of injection. On discharge, 4 days later there was only slight tenderness. The patient was seen again over the next 2 weeks and there appeared to be no residual effects. She was informed of the situation and given a warning letter in the attempt to avoid the same problem again.

The key factor in diagnosis of intra-arterial injection of thiopentone is excruciating pain at the site of injection because of the high alkalinity of the solution and possibly crystal embolisation, resulting in intense vasospasm with potential for tissue ischaemia. This leads to a delay in onset of anaesthesia. There was only an initial discomfort in this case and no delay in induction of anaesthesia, and we can attribute this to the use of lignocaine before the thiopentone. The lignocaine would effectively cause anaesthesia of the intima and dilatation of the vessel and render it resistant to spasm. This is a previously unrecognised situation: the prevention of spasm because of pretreatment with lignocaine which resulted in rapid and complete recovery.

The lessons we have learnt are that pain on intravascular injection of lignocaine may signify arterial administration and that aberrant arteries can be very deceptive in both appearance and location.

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Northern Ireland

M.S. McKinney
I.M. Bali

Labelling of glycopyrronium/neostigmine mixture

The recent introduction of glycopyrronium/neostigmine mixture (Robinul/neostigmine, A.H. Robins) is economic and convenient. The product name and pharmacological details are printed on a plastic label adhered to the ampoule; however, we have recently discovered that the label easily peels off which leaves unmarked the 1 ml brown glass ampoule. The label can be very conveniently used to mark a syringe which contains the mixture but could also mask the contents of other similar ampoules. For example, when wrapped around an ampoule of neostigmine (Antigen) it is possible to accept this as glycopyrronium/neostigmine mixture. This must be viewed as a potential hazard in view of the recent publicity in the press concerning sabotage of anaesthetic equipment. We have notified the manufacturers who are now investigating this defect.

We have examined ampoules of all other commonly used anaesthetic agents and have been unable to remove intact the plastic labels.

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A.P. Vickers
A.L. Baldam

Neuropraxia of the mental nerve

A thirty-five-year-old woman had a right hemicolectomy for Crohn's disease, complicated by stricture formation and ileocolic fistulae. The operation was conducted under routine, uneventful general anaesthesia. Induction was with thiopentone and midazolam and orotracheal intubation with a 7.5-mm tracheal tube. Anaesthesia was maintained with halothane, pancuronium, and fentanyl and lasted 4 hours. Reversal of relaxation with neostigmine and atropine was uneventful. The right half of the lower lip was everted after extubation. We did not attach any significance to this observation and restored the lower lip to its normal position.

The patient complained of numbness of the right half of the lower lip the next day; it was described as similar to the numb feeling after dental treatment under local anaesthesia. The anaesthesia of the lower lip involved the medial two thirds of the mucosal lining of the right half of the lower lip, the skin of the lip down to the chin and the gingival mucosal lining of the right mandibular teeth: the two incisors, canine and first premolar. The sensation over the lingual aspect of the gingiva was not affected. There was no motor deficit of any of the muscles of the lower lip; all the mimic movements were intact. Touch, pain, heat and cold were affected but proprioception was not. We assumed it occurred as a result of traction/compression neuropraxis of the mental branch of the mandibular division of the trigeminal nerve, and anticipated full recovery. Three weeks after the operation, sensation of the lower lip recovered from lateral to medial, which left a little strip of anaesthesia on the very medial region of the lower lip; this disappeared during the next 2 weeks, without any complaint of paraesthesiae.

Injury to peripheral nerves may occur during general anaesthesia, by intraneuronal ischaemia as a result of compression against a bony prominence and (or) traction injury because of inappropriate position. Neuropraxis of the brachial plexus, ulnar nerve, radial nerve, common peroneal nerve, lateral cutaneous nerve of the thigh and of the mandibular branch of the facial nerve are well known.[1] Injury to a motor nerve is disabling and immediately noticed whereas sensory loss in the postoperative period is less frequent and requires an alert and intelligent patient.

The mental nerve is a purely sensory nerve; injury to it causes numbness.[2] The lower lip is fleshy, well padded and elastic, but the mental branch is vulnerable to combined compression or traction injury since it is fixed at one end in the mandibular canal. Traction or compression ischaemic neuropraxis may be caused by compression from the extra-oral segment of the tracheal tube; extra traction by the method of fixation of the tube which everts the lower lip inadvertently may aggravate this.[3] The nerve recovered[4] similar to any short term ischaemic neuropraxia, but this minor, unpleasant inadvertent complication is preventable.

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References

1. Ahearn RS. Minor complications of anesthesia. In: Gray TC, Nunn JF, Utting JE. *General anaesthesia*, 4th edn. London: Butterworths, 1980: 1984–5.
2. Roistacher SL. Numbness—a significant finding. *Oral Surgery, Oral Medicine and Oral Pathology* 1973; **36:** 22–7.
3. Nulsen FE, Kline DG. Acute injury of peripheral nerves; In: Youmans JR. *Neurological surgery*. Philadelphia, London, Toronto: W.B. Saunders, 1973: 1089–140.
4. Levant BA. Mental anesthesia and its prognosis. *British Journal of Oral Surgery* 1967; **4:** 206–12.

Anaesthesia and thalidomide-related abnormalities

A 26-year-old, 50 kg female who had severe phocomelia, presented with menorrhagia and was scheduled for dilatation and curettage. Her head and trunk were of normal adult size, but both upper and lower limbs were absent, apart from small deformed hands and feet. There was an almost total lack of visible peripheral veins.

An ECG monitor was attached to the patient before induction of anaesthesia; application of a sphygmomanometer cuff, however, was impossible. Anaesthesia was induced by inhalation of halothane (increasing in concentration from 0.5–2%) in nitrous oxide and oxygen after two unsuccessful attempts to cannulate a vein on the dorsum of the foot. Induction was achieved with surprising rapidity; plane 2 of surgical anaesthesia was reached within 2 minutes. The heart rate had decreased from 115 to 55 beats/minute, and changed from sinus to nodal rhythm. Anaesthesia was lightened by decreasing the inspired concentration of halothane to 1%. Once again, this was achieved quickly. The planned procedure was carried out; anaesthesia was maintained adequately with 1–1.5% halothane. Recovery was equally rapid with the patient awake and responsive within 60 seconds of turning off the halothane and nitrous oxide.

Between 350 and 400 thalidomide-affected children survived the postnatal period in the United Kingdom[1] and will now be aged 25–30 years. The condition is associated with abnormalities other than phocomelia.[2] These include a depressed nasal bridge, strabismus, coloboma, profuse sweating, spinal abnormalities and congenital heart defects. There have been no reports of anaesthesia for these pati-

Table 1. Distribution of skeletal muscle in the normal female aged 22–36 years (taken from Report of the Task Group on Reference Man[4]).

		Distribution		
Tissue	% body weight	Arms	Legs	Head and trunk
Skeletal muscle	30%	20%	55%	25%

ents. Indeed, the literature on the anaesthetic management of patients with pathologically small stature in general, is scanty[3,4] and is concerned mainly with the problems of anaesthesia for achondroplastic dwarfs. These include awkward and hazardous tracheal intubation, difficulty in finding the extradural space and the predisposition towards postoperative hypoxia as a result of thoracic kyphoscoliosis.

This patient's head, trunk and (presumably) 'vessel rich' group of organs were normal in size, but the absence of limbs would imply a 75% reduction in total body skeletal muscle mass (see Table 1). This small muscle mass poorly buffers any increase or decrease in inspired anaesthetic vapour tension and may explain the surprising rapidity of induction and subsequent fluctuations in depth of anaesthesia observed in this patient.

Several other points, peculiar to the provision of anaesthesia for the amelic patient, are worth mention. Potential sites for venous access will be limited. Internal or external jugular veins may provide the only practical routes of venous access if peripheral veins are nonexistent and femoral or subclavian veins are poorly formed. Profuse sweating may make ECG electrode adhesive unreliable. Finally, the estimation of blood pressure may be impossible if there are no limbs upon which to apply a sphygmomanometer cuff, and a peripheral artery suitable for cannulation cannot be found.

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References

1. Ministry of Health. Deformities caused by thalidomide. *Reports on public health and medical subjects*, No. 112. HMSO London, 1964.
2. Fletcher I. Review of the treatment of thalidomide children with limb deficiency in Great Britain. *Clinics in Orthopaedics* 1980; **148:** 18–25.
3. Walts LF, Finerman G, Wyatt G. Anaesthesia for dwarfs and other patients of pathological small stature. *Canadian Anaesthetists' Society Journal* 1975; **22:** 703–9.
4. Kalla GN, Fening E, Obiaya MO. Anaesthetic management of achondroplasia. *British Journal of Anaesthesia* 1986; **58:** 117–9.
5. Report of the Task Group on Reference Man. *International Commission on Radiological Protection*, No. 23. Pergamon Press, 1975.

Lignocaine gel 2% per rectal as an adjunct to general anaesthesia for anal stretch

The surgical procedure of anal stretch results in severe reflex responses presumably at least partially as a result of pain called the Brewer-Luckhardt reflex (laryngeal spasm and movement of body muscles). Deep anaesthesia, supplementary analgesia, short acting muscle relaxant or regional analgesia are employed to overcome these potentially hazardous responses.[1] Light general anaesthesia is said to have no place in surgery for anal stretch.

Lignocaine gel 2%[2] (20 ml tube, each ml contains 20 mg lignocaine hydrochloride) is used widely for surface analgesia during urethral catheterisation[3,4] and in the oesophagus for oesophageal dilatation.[5] The gel is also used during the insertion of a nasogastric tube; the dose was more than 400 mg but no side effects were seen.

This study explored the use of lignocaine gel 2% per rectum. Twenty patients, ASA 1 and 2, aged 18–65 years scheduled for examination under anaesthesia and anal stretch were examined. They were given verbal information and consent was obtained. The study was approved by the local hospital ethics committee. All the patients received lorazepam 2 mg orally 2 hours before operation and were allocated randomly into two groups. Group one received K-Y jelly 20 ml and group two 20 ml of lignocaine gel 2% per rectum with the help of an applicator 15 minutes before anaesthesia. The anaesthetist was not aware of the agents used. Blood pressure, heart rate and breathing frequency were noted before induction, 5 minutes after induction, during anal stretch and postoperatively for 30 minutes.

Anaesthesia was induced with propofol 3 mg/kg, after alfentanil 7.5 μg/kg and metoclopramide 5 mg. Anaesthesia was maintained with 70% N_2O in oxygen and enflurane 2%. The patients were allowed to breathe spontaneuously for 5 minutes through a Bain system and mask before surgery proceeded. Abnormal movement, stridor, laryngospasm and other incidents were noted at the start of surgery and inadequate anaesthesia was deepened with an increment of propofol and increased enflurane; if these were ineffective halothane was substituted.

All the patients in K-Y jelly group had features of inadequate anaesthesia and surgery was interrupted. There was a significant increase in the heart rate, respiratory rate and increased blood pressure. All the patients moved during anal stretch and there was a high incidence of inspiratory stridor; laryngospasm occurred in one case.

The patients in the lignocaine group had an increase in heart rate, respiratory rate and blood pressure but this was not significant. There were minor movements in three patients but not sufficient to interrupt surgery. There was no instance of laryngospasm or inspiratory stridor (apart from one case in whom surgery was delayed for 2 hours, by which time perhaps there was no effect of lignocaine). None of the patients exhibited any side effects of lignocaine.

Lignocaine gel 2% per rectum given 15 minutes before anaesthesia for anal stretch reduces the need for deep general anaesthesia and decreases the severe reflex responses.

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References

1. Atkinson RS, Rushman GB, Lee JA. *A synopsis of anaesthesia*. London: Wright, 1982.
2. Abpi Data Sheet Compendium 1987–88.
3. Axelsson K, Jozwiak H, Lingardh G, Schonebeck J, Widman B. Blood concentration of lignocaine after application of 2% lignocaine gel in the urethra. *British Journal of Urology* 1983; **55:** 64–8.
4. Quellette RD, Blute R, Jaffee S, Bahde C. Plasma concentrations of lidocaine resulting from instillation of lidocaine jelly into genitourinary tract prior to cystoscopy. *Urology* 1985; **25:** 490–1.
5. Degn H, Bodker A, Rasmussen E, Rassmussen JP. The possible systemic effect of lidocaine gel administered orally. *Acta Anaesthesiologica Scandinavica* 1982; (Suppl. 72 Abstract 71): 86.
6. Nydahl PA, Axelsson K. Venous blood concentration of lidocaine after nasopharyngeal application of 2% lidocaine gel. *Acta Anaesthesiologica Scandinavica* 1988; **32:** 135–9.

Small was beautiful

It was with regret that we opened our first copies of *Anaesthesia* in 1988. Obviously, as the editor said, the page size had indeed grown. Turning rapidly to his editorial for a justification of this transmogrification, we found none. What does 'the inevitable march of time' mean? Why should anaesthetists copy their contemporaries? Our shelves are *not* easily adaptable (we are not sure that the library's are either)! Surely there are other ways to shorten the period between acceptance and publication?

Lest you think this letter too carping we congratulate you on the success of *Anaesthesia News* but remain deeply aggrieved that our favourite pocket sized anaesthetic journal and the journal of our Association has been so radically altered without so much as a by our leave. Small is still beautiful!

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N.F. Harley
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G.R. Sowden
N.P. O'Donovan
P.W. Brighten
S.J. Forster

A reply

A few friends have made similar comments but, in general, it must be said that the overall response to the change in size is positive. Inspection of library shelves reveals that most journals, not just those of our discipline, are in the large page format. Authors probably want their articles in a form that will stand the test of time and not suffer the fate of material that can be crammed into the pocket of a white coat. There *are* other ways to reduce the interval between acceptance and publication and the Editors try to do this constantly, but the progressive increase in bulk of the journal demanded further action. We hope that everyone will accommodate to the change soon.

Anaesthesia News was started as an experiment and I described it as a success. Some have criticised this too, but in unpublishable terms. The experiment had the following hypothesis: can we remove the ephemeral, but important, material to make space for more articles and yet continue to supply our members (as distinct from subscribers) with what they want and accomplish this more quickly? The conclusion is that *Anaesthesia News* can and does do this; so, in this sense, the experiment is a success. The fact that perforce the format of *that* is not acceptable to the majority of members has become apparent and the Editorial Board are planning changes. Members should recall that non-ephemeral details of the activities of the Association of Anaesthetists of Great Britain and Ireland are included in the Journal as the report of the Linkman Conference and the Annual Report of Council. History can thus be served.

Editor

Anaesthesia, 1988, Volume 43, pages 616–617

Book reviews

Radiology for anaesthesia and critical care
Edited by C.H. MURPHY AND M.H. MURPHY 616
Complications in critical care medicine
Edited by P.D. LUMBARD AND C.W. BRYAN-BROWN 616
Foundations of obstetric anaesthesia
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Radiology for anaesthesia and critical care

Edited by C.H. MURPHY AND M.H. MURPHY. Pp. xii + 273. Churchill Livingstone, 1987. £37.50.

This well written book is edited by a radiologist and an anaesthetist and, although it is principally aimed at anaesthetists, it would be of value to the radiologist involved in film interpretation for intensive care. It is profusely illustrated and the radiographs are consistently reproduced to a high standard.

It is introduced with an explanation of the X ray image, and gives a good, lucid description of the basic properties of X rays and the mechanism by which the image is produced to enable a rational interpretation of the radiograph, including how to read the film in a routine manner.

The chest radiology includes chapters on pre-operative evaluation, parenchymal densities, adult respiratory distress syndrome and trauma to the pleura and mediastinum with a proper emphasis on plain films. The short chapter on the abdomen, which also emphasises plain film findings, includes several examples of pre-operative support devices to be recognised on the radiographs. This is followed by a comprehensive account of monitoring and life support devices as they appear on film, including the position of tracheostomy and nasogastric tubes. There are multiple pertinent references at the end of each chapter.

A section on the management of special imaging techniques is included although it is recognised that these cannot be performed at the bedside. The support and organisation required to transfer the patient to the Radiology Department for a more complex procedure is discussed. There are several multi-author chapters on the radiology of paediatric patients including neonates, with numerous examples of the variety of congenital lung abnormalities that can be difficult to interpret.

The inclusion of a chapter which discusses methods of anaesthesia for radiological procedures will be welcomed by both disciplines, particularly the sections that concern the anaesthetic management of bronchography and neuroradiological investigations. The shortcomings and dangers of sedation as a means of procuring cooperation from infants and children are discussed. General anaesthesia is preferred because of its logistic benefits which provide a high yield of satisfactory investigations and safer monitoring conditions. There is emphasis of the special requirements for producing suitable conditions for CT scanning and magnetic resonance imaging. A concise summary of the types of reactions which are likely to be associated with radiological contrast media is included. It concludes with a brief account of Radiation Safety which is reassuring to the clinician who is exposed intermittently to diagnostic radiation and who may be unsure of the guidelines.

This book deserves a place in both anaesthetic and radiology libraries and would also be a valuable bench book in the Intensive Care Unit. However a nagging fear is that anaesthetists and intensivists, having once read this excellent volume, will consider themselves to be sufficiently expert that they become immune to advice from professionals. This is, we suspect, unlikely, since the text reveals subtleties of diagnosis which are more likely to widen the perceptive horizons of the reader than to obscure judgment with convenient diagnostic gimmicks.

It is thoroughly recommended for reference, browsing and (part) ownership. Had it not been published, we (radiologist and anaesthetist) would have had to undertake the task ourselves.

M.R. JONES
P.L. JONES

Complications in critical care medicine

Edited by P.D. LUMBARD AND C.W. BRYAN-BROWN. Pp. xv + 358. Year Book Medical Publishers, Inc., 1988. £41.50.

It is not possible to cover the complications of critical care medicine in a text which consists of merely 340 pages, since at one time or other, almost all known medical and surgical complications have occurred in this area. The editors have therefore chosen to concentrate on the main areas of interest for example, mechanical ventilation, shock, infection, nutrition, drugs, cardiovascular monitoring and organ transplantation.

Each chapter can be read independently of all the others, all are adequately referenced but some are grossly over-referenced. Inspite of a thorough review of complications of mechanical ventilation (with over 200 references) there is little new to the experienced intensive care specialist. Trainees in anaesthesia and intensive therapy would however gain much.

Few of the chapters confine themselves to complications, for example the section on acute renal failure would be better placed in a general text book, useful though it is, and the chapter on septic shock discusses the mechanisms in some detail before addressing the question of complications.

Invasive monitoring has become a cornerstone of intensive care practice, so much so that we accept the need for it uncritically. The two chapters on pulmonary artery catheters and interpretation of systemic pressure monitoring should be essential reading for all, emphasising, as they do, the need not only for accurate measurements but also intelligent interpretation. All too often, we forget that monitoring is not, of itself, curative.

Nutrition is, I hope, accepted by most as an essential part of therapy in critical illness. It is somewhat surprising therefore that a large section of the chapter on nutrition-related complications is devoted to the consequences of *not* feeding. Irritatingly, concentrations of electrolytes are expressed in mEq and not mmol. Protein intolerance is mentioned as a cause of rising blood urea, and caloric overloading is covered adequately but there is no mention of inadequate calorie provision as an equally important cause for protein intolerance.

Drug reactions and interactions are covered well with due emphasis on altered pharmacokinetic variables in critical illness and therefore the need for monitoring drug concentrations. Intensive care unit design is also described and anyone currently planning a new unit would find interest here. The final chapter of this useful book addresses the question of finance. I suspect that the message will have relevance in Europe before too long although it is primarily of interest to American readers at present.

So who will benefit from reading this book? The consultant with an intensive care interest will certainly find it useful but I think that its main readership should consist of candidates for the final part of the FFARCS examination and their examiners.

E. MAJOR

Foundations of obstetric anaesthesia

Edited by B.M. MORGAN. Pp. 309. Farrand Press, 1987. £19.80.

The past decade has seen a steady increase in the number of short 'crammer' courses on specific aspects of anaesthetic practice and one of the best known of the kind is the annual teach-in course at Queen Charlotte's Maternity Hospital. The regular high attendance at this course attests to the popularity of such intense teaching sessions. This book has been published in response to the demand of participants at this course for a written account of the presented material.

The intention of this book is to offer an account of a coordinated multi-disciplinary approach to perinatal care with an emphasis on the special interests of anaesthetists in training. The editor has combined chapters from anaesthetists and nonanaesthetists (obstetricians, paediatricians, haematologists). The list of contributors is impressive and reads like a 'who's-who' of obstetrics and obstetric anaesthesia. The overall range of topics covered is admirable but the reviewer is at a slight loss to understand the order in which they are covered. For example, aspects of physiology associated with pregnancy does not appear until the eighth chapter, well after all aspects of obstetric epidurals, spinals and general anaesthesia have been covered. Surely, an understanding of physiological changes is important to comprehend which changes occur during anaesthesia?

There are some aspects of practice which could have received more attention; for example, the management of difficult or failed tracheal intubation in obstetrics. There is little mention of additional equipment for difficult intubation that should be immediately available and there is very little guidance about the decision to abandon tracheal intubation. Notwithstanding these small criticisms, the information contained in this book is well suited to anaesthetists in training.

It is usual practice for reviewers not to draw attention to specific printing errors but this book contains more than the average number. Indeed, in one chapter the errors reach a peak of three in a single page. Some of the diagrams, although well presented, have the wrong captions, or are not easily understood. Such levels of errors are distracting to the reader and your reviewer believes are worthy of mention in a review.

Will the publication of this book affect attendances at the Queen Charlotte's course and reduce attendances? This is doubtful because clinical practice often changes rapidly and such annual 'teach-ins' are an invaluable aid to keeping up to date. Hence, although this book may not be a complete substitute for attending the course, at £19.80 it costs less than a second class return ticket to London from most parts of the United Kingdom and so must represent good value for money.

M. HARMER

Books received

We thank publishers for the following books which may be reviewed in future issues of *Anaesthesia.*

Clinical anaesthesia procedures of the Massachusetts General Hospital, 3rd edn.
Edited by L.L. FIRESTONE, P.W. LEBOWITZ, AND C.E. COOK. Pp. x + 728. Little, Brown and Co, 1988.

Regional anaesthesia
M. ZENZ, C. PANHANS, H. CHR. NIESEL AND H. KREUSCHER. Pp. 243. Wolf Medical Publications, 1988.

Understanding anaesthesia, 2nd edn.
L.E.S. CARRIE AND P.J. SIMPSON. Pp. xii + 501. Heinemann Medical Books Ltd, 1988.

Anaesthesia, 1988, Volume 43, pages 618–621

Anaesthetic literature

This section of *Anaesthetic Literature* contains references taken from *Current Contents—Life Sciences* for March 1988. The Journals which may be consulted when *Anaesthetic literature* is compiled are those listed in *Current Contents—Life Sciences*, published by the Institute of Scientific Information, Philadelphia, Pennsylvania, USA.

Abdominal surgery

Dopamine and norepinephrine in the gastrointestinal tract of mice and the effects of neurotoxins. Eaker EY, Bixeler GB *et al. Journal of Pharmacology and Experimental Therapeutics* 1988; **244:** 438.

Pulmonary complications after upper abdominal surgery—their prevention with intercostal blocks. Engberg G, Wiklund L. *Acta Anaesthesiologica Scandinavica* 1988; **32:** 1.

Neuroendocrine potential of the colon and rectum. Lluis F, Thompson JC. *Gastroenterology* 1988; **94:** 832.

Physiology and pathophysiology of gastrin—a review. Mulholland MW, Debas HT. *Surgery* 1988; **103:** 135.

The gut as source of sepsis after hemorrhagic shock. Sori AJ, Rush BF Jr *et al. American Journal of Surgery* 1988; **155:** 187.

Intestinal endotoxemia. Clinical significance. Van Deventer SJH. *Gastroenterology* 1988; **94:** 825.

Pharmacology

Adrenergic drugs and their antagonists

Selective beta 1-adrenoceptor blockade and muscle thermogenesis. Fagher B, Monti M, Thulin T. *Acta Medica Scandinavica* 1988; **223:** 139.

Blunted beta-adrenergic responsivity of peripheral blood mononuclear cells in endogenous depression. Halper JP, Brown RP *et al. Archives of General Psychiatry* 1988; **45:** 241.

Effects of atropine and propranolol on the respiratory, circulatory, and ECG responses to high altitude in man. Koller EA, Drechsel S *et al. European Journal of Applied Physiology and Occupational Physiology* 1988; **57:** 163.

Pharmacokinetic and pharmacodynamic interactions between nisoldipine and propranolol. Levine MAH, Ogilvie RI, Leenen FHH. *Clinical Pharmacology and Therapeutics* 1988; **43:** 39.

Alpha- and beta-adrenergic receptor function in the brain during senescence. Scarpace PJ, Abrass IB. *Neurobiology of Aging* 1988; **9:** 53.

Anaesthetic agents

The P–300 event-related potential in experimental nitrous oxide exposure. Estrin WJ, Moore P *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 86.

The effects of nitrous oxide on P300 and reaction time. Fowler B, Kelso B *et al. Electroencephalography and Clinical Neurophysiology* 1988; **69:** 171.

Pharmacological profiles in vivo of benzodiazepine receptor ligands. Gardner CR. *Drug Development Research* 1988; **12:** 1.

Zolpidem and related compounds—syntheses, physical properties and structure-activity relationships. George P, Rossey G *et al.* In: Sauvanet JP *et al.*, eds. *Imidazopyridines in sleep disorders.* New York: Raven Press, 1988: 11.

Influence of the rate of hepatic portal vein infusion on hexobarbital pharmacokinetics in the rat. Joeres RP, Vermeulen NPE, Breimer DD. *Pharmacology* 1988; **36:** 210.

Pharmacokinetic implications for the clinical use of atropine, scopolamine and glycopyrrolate. Kanto J, Klotz U. *Acta Anaesthesiologica Scandinavica* 1988; **32:** 69.

General anesthesia and postnarcotic sleep disorders. Lehmkuhl P, Prass D, Pichlmayr I. *Neuropsychobiology* 1987; **18:** 37.

Peripheral analgesic action of clonidine: mediation by release of endogenous enkephalin-like substances. Nakamura M, Ferreira SH. *European Journal of Pharmacology* 1988; **146:** 223.

Effects of treatment with phenobarbitone or isoniazid on hepatotoxicity due to prolonged subanaesthetic halothane inhalation. Plummer JL, Hall P De La M *et al. Pharmacology and Toxicology* 1988; **62:** 74.

Heterogeneity of benzodiazepine receptors. Sieghart W. In: Sauvanet JP *et al.*, eds. *Imidazopyridines in sleep disorders.* New York: Raven Press, 1988: 39.

Atropine- and endothelium-dependent relaxation. Thomas G, Mostaghim R, Ramwell PW. *European Journal of Pharmacology* 1988; **145:** 361.

Analgesic agents

A clinical trial of buprenorphine: comparison with methadone in the detoxification of heroin addicts. Bickel WK, Stitzer ML *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 72.

Structure-activity relationships for drugs binding to the agonist and antagonist states of the primary morphine receptor. Cheney BV. *Journal of Medicinal Chemistry* 1988; **31:** 521.

Protection by opioids against gastric lesions caused by necrotizing agents. Ferri S, Speroni E *et al. Pharmacology* 1988; **36:** 140.

Pharmacokinetics and pharmacodynamics of codeine in end-stage renal disease. Guay DRP, Awni WM *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 63.

Cardiohemodynamic and respiratory effects of eptazocine, a new analgesic agent, in anesthetized dogs. Kimura T, Murakami H *et al. Folia Pharmacologica Japonica* 1988; **91:** 151.

An investigation into the possible development of chronic tolerance to analgesia and dependence on prolactin. Ramaswamy S, Venkatadri N, Bapna JS. *Fundamental and Clinical Pharmacology* 1987; **1:** 445.

Prolonged morphine treatment increases rat brain dihydropyridine binding sites: possible involvement in development of morphine dependence. Ramkumar V, El-Fakahany EE. *European Journal of Pharmacology* 1988; **146:** 73.

Muscle relaxants

Residual curarisation—a comparative study of atracurium and pancuronium. Andersen BN, Madsen JV *et al. Acta Anaesthesiologica Scandinavica* 1988; **32:** 79.

The Ca2+ —pumping ATPase and the major substrates of the cGMP-dependent protein kinase in smooth muscle sarcolemma are distinct entities. Baltensperger K, Carafoli E, Chiesi M. *European Journal of Biochemistry* 1988; **172:** 7.

Feedback control of transmitter release at the neuromuscular junction. Bowman WC, Marshall IG *et al. Trends in Pharmacological Sciences* 1988; **9:** 16.

The collator of this section is Dr L. Kaufman, MD, FFARCS, Anaesthetic Office, The Rayne Institute, University College, University Street, London WC1E 6JJ. Dr Kaufman is prepared to provide on request a new additional service to our readers. References from January 1984 have been entered on data base using Dbase III Plus (MsDos) and this will be upgraded in the near future to Dbase IV. The program which provides search facilities will be available free of charge save for the cost of the disk. In addition, all the data on a yearly or monthly basis will be available at a modest charge. Enquiries direct to Dr Kaufman at the above address please.

Malignant hyperthermia—relationship to other diseases. Brownell AKW. *British Journal of Anaesthesia* 1988; **60:** 303.

Human muscle fatigue: frequency dependence of excitation and force generation. Cooper RG, Edwards RHT *et al. Journal of Physiology* 1988; **397:** 585.

The significance of simultaneous estimation of serum creatine kinase and myoglobin in neuromuscular diseases. Dioszeghy P, Mechler F. *Journal of Neurology* 1988; **235:** 174.

A simple and rapid method for the determination of the concentrations of magnesium, sodium, potassium and sodium, potassium pumps in human skeletal muscle. Dorup I, Skajaa K, Clausen T. *Clinical Science* 1988; **74:** 241.

Malignant hyperthermia myopathy—a critical review. Harriman DGF. *British Journal of Anaesthesia* 1988; **60:** 309.

Dantrolene—dynamics and kinetics. Harrison GG. *British Journal of Anaesthesia* 1988; **60:** 279.

Malignant hyperthermia—biochemical aspects of the acute episode. Heffron JJA. *British Journal of Anaesthesia* 1988; **60:** 274.

Esophageal manometric studies in patients with myasthenia gravis. Huang MH, King KL, Chien KY. *Journal of Thoracic and Cardiovascular Surgery* 1988; **95:** 281.

Electromyography and fatigue during prolonged, low-level static contractions. Jorgensen K, Fallentin N *et al. European Journal of Applied Physiology and Occupational Physiology* 1988; **57:** 316.

Pathogenesis of myasthenia gravis: acetylcholine receptor-related antigenic determinants in tumor-free thymuses and thymic epithelial tumors. Kirchner T, Tzartos S *et al. American Journal of Pathology* 1988; **130:** 268.

Thymus in myasthenia gravis. Isolation of T-lymphocyte lines specific for the nicotinic acetylcholine receptor from thymuses of myasthenic patients. Melms A, Schalke BCG *et al. Journal of Clinical Investigation* 1988; **81:** 902.

Motor nerve ending disorder in myasthenia gravis. Roe RD, Riker WF, Standaert FG. *Neurology* 1988; **38:** 293.

Clinical presentation of malignant hyperthermia. Rosenberg H. *British Journal of Anaesthesia* 1988; **60:** 268.

Chloroquine myopathy and myasthenia-like syndrome. Sghirlanzoni A, Mantegazza R *et al. Muscle and Nerve* 1988; **11:** 114.

Muscle blood flow during isometric activity and its relation to muscle fatigue. Sjogaard G, Savard G, Juel C. *European Journal of Applied Physiology and Occupational Physiology* 1988; **57:** 327.

Other drugs

Surfactant effects in topical drug availability. Ashton P, Hadgraft J *et al. International Journal of Pharmaceutics* 1988; **41:** 189.

Interactions between calcium channel blockers and non-cardiovascular drugs: interactions with drugs acting at the neuromuscular or the CNS level. Baeyens JM, Del Pozo E. *Pharmacology and Toxicology* 1988; **62:** 59.

Time course of blood volume change with carbon monoxide inhalation and its contribution to the overall cardiovascular response. Davidson SB, Penney DG. *Archives of Toxicology* 1988; **61:** 306.

Drug therapy: beta-lactam antibiotics (first of two parts). Donowitz GR, Mandell GL. *New England Journal of Medicine* 1988; **318:** 419.

Drug therapy: beta-lactam antibiotics (second of two parts). Donowitz GR, Mandell GL. *New England Journal of Medicine* 1988; **318:** 490.

Hypotensive effect of bromocriptine in glaucomatous eyes. Geyer O, Robinson D, Lazar M. *Journal of Ocular Pharmacology.* 1987; **3:** 291.

Cardiovascular toxicity and tricyclic antidepressants. Jackson WK, Roose SP, Glassman AH. *Biomedicine and Pharmacotherapy* 1987; **41:** 377.

Pharmacokinetic drug interactions between triamterene and ranitidine in humans—alterations in renal and hepatic clearances and gastrointestinal absorption. Muirhead M, Bochner F, Somogyi A. *Journal of Pharmacology and Experimental Therapeutics* 1988; **244:** 734.

The effect of droperidol on fentanyl-influenced gastric emptying in man. Petring OU, Adelhoj B *et al. Acta Anaesthesiologica Scandinavica* 1988; **32:** 21.

Paraquat poisoning by skin absorption: a review. Smith JG. *Human Toxicology* 1988; **7:** 15.

Monoamine oxidase inhibitors and anaesthesia—a review. Stack CG, Rogers P, Linter SPK. *British Journal of Anaesthesia* 1988; **60:** 222.

System approaches in pharmacokinetics. 1. Basic concepts. Vengpedersen P. *Journal of Clinical Pharmacology* 1988; **28:** 1.

Apparatus

A single-blind study of pulse oximetry in children. Cote CJ, Goldstein EA *et al. Anesthesiology* 1988; **68:** 184.

Recommendations for human blood pressure determination by sphygmomanometers. Frohlich ED, Grim C *et al. Circulation* 1988; **77:** A502.

A finger volume-oscillometric device for monitoring ambulatory blood pressure: laboratory and clinical evaluations. Imai Y, Nihei M *et al. Clinical and Experimental Hypertension,* Part A 1987; **9:** 2001.

Evaluation of a hand-held spirometer, the respiradyne, for the measurement of FEV_1, FVC and PEFR. Jenkins SC, Barnes NC, Moxham J. *British Journal of Diseases of the Chest* 1988; **82:** 70.

Transcutaneous oxygen tension as a predictor of success after an amputation. Wyss CR, Harrington RM *et al. Journal of Bone and Joint Surgery* 1988; **70A:** 203.

Complications

Amiodarone-induced pneumonitis—assessment of risk factors and possible risk reduction. Adams GD, Kehoe R *et al. Chest* 1988; **93:** 254.

Stress-induced malignant hyperthermia in a head-injured patient. Feuerman T, Gade GF, Reynolds R. *Journal of Neurosurgery* 1988; **68:** 297.

Papaverine-induced coma. Ilan Y, Gemer O. *European Journal of Clinical Pharmacology* 1988; **33:** 651.

Amiodarone pulmonary toxicity—biochemical evidence for a cellular phospholipidosis in the bronchoalveolar lavage of human subjects. Martin WJ, Standing JE. *Journal of Pharmacology and Experimental Therapeutics* 1988; **244:** 774.

Toxic effects of drugs on erythrocytes. Morse EE. *Annals of Clinical and Laboratory Science* 1988; **18:** 13.

Profound reversible myocardial depression after anaphylaxis. Raper RF, Fisher M McD. *Lancet* 1988; **1:** 386.

Nontraumatic prehospital sudden death in young adults. Raymond JR, Vandenberg EK, Knapp MJ. *Archives of Internal Medicine* 1988; **148:** 303.

Induction, prevention and mechanisms of contrast media-induced acute renal failure. Vari RC, Natarajan LA *et al. Kidney International* 1988; **33:** 699.

The neuropsychiatry of post-traumatic stress disorder. Watson IPB, Hoffman L, Wilson GV. *British Journal of Psychiatry* 1988; **152:** 164.

Association between necropsy evidence of disseminated intravascular coagulation and coagulation variables before death in patients in ICU. Wilde JT, Roberts KM *et al. Journal of Clinical Pathology* 1988; **41:** 138.

General anaesthetic procedures

Should the pill be stopped preoperatively? Sue-Ling H, Hughes LE. *British Medical Journal* 1988; **296:** 447.

General interest

Diagnosis and treatment of aphasia: Part II. Albert ML, Helm-Estabrooks N. *Journal of the American Medical Association* 1988; **259:** 1205.

The pathogenesis of acute pancreatitis. Barry RE. *British Medical Journal* 1988; **296:** 589.

A histological and histochemical study of the cricopharyngeus muscle in man. Bonington A, Mahon M, Whitmore I. *Journal of Anatomy* 1988; **156:** 27.

Hypothesis: sepsis, multiple systems organ failure, and the macrophage. Border JR. *Archives of Surgery* 1988; **123:** 285.

A review of the ethical and legal aspects of terminating medical care. Emanuel EJ. *American Journal of Medicine* 1988; **84:** 291.

There is life outside the operating room. Hatcher CR Jr. *Annals of Thoracic Surgery* 1988; **45:** 117.

Phaeochromocytoma without symptoms: desensitization of the alpha- and beta-adrenoceptors. Krause M, Reinhardt D, Kruse K. *European Journal of Pediatrics* 1988; **147:** 121.

Transient weakness and altered membrane characteristic in recessive generalized myotonia (Becker). Rudel R, Ricker K, Lehmann-Horn F. *Muscle and Nerve* 1988; **11:** 202.

Local analgesia

Clinical assessment of a two-compartment Bayesian Forecasting Method for lidocaine. Beach CL, Farringer JA *et al. Therapeutic Drug Monitoring* 1988; **10:** 74.

Rapid gas-chromatographic assay of bupivacaine in plasma. L Normand Y, Athouel A *et al. Fundamental and Clinical Pharmacology* 1987; **1:** 471.

H2 antagonists and bupivacaine clearance. O'Sullivan GM, Smith M *et al. Anaesthesia* 1988; **43:** 93.

Spinal and epidural analgesia

Anatomy of the human lumbar epidural space: new insights using CT-epidurography. Savolaine ER, Pandya JB *et al. Anesthesiology* 1988; **68:** 217.

Posture and post-spinal headache—a controlled trial in 80 obstetric patients. Thornberry EA, Thomas TA. *British Journal of Anaesthesia* 1988; **60:** 195.

Spinal opioids

CSF morphine levels after lumbar intrathecal administration of isobaric and hyperbaric solutions for cancer pain. Caute B, Monsarrat B *et al. Pain* 1988; **32:** 141.

Epidural opiates and urinary retention: new models provide new insights. Dray A. *Anesthesiology* 1988; **68:** 323.

Opioid peptides and metabolic regulation. Giugliano D, Torella R *et al. Diabetologia* 1988; **31:** 3.

Dynorphin A-(1–13) attenuates withdrawal in morphine-dependent rats: effect of route of administration. Green PG, Lee NM. *European Journal of Pharmacology* 1988; **145:** 267.

Multiple morphine and enkephalin receptors and the relief of pain. Pasternak GW. *Journal of the American Medical Association* 1988; **259:** 1362.

Efficacy of 0.3 mg morphine intrathecally in preventing tourniquet pain during spinal anaesthesia with hyperbaric bupivacaine. Tuominen M, Valli H *et al. Acta Anaesthesiologica Scandinavica* 1988; **32:** 113.

Obstetric anaesthesia and analgesia

Active management of labor and operative delivery in nulliparous women. Akoury HA, Brodie G *et al. American Journal of Obstetrics and Gynecology* 1988; **158:** 255.

Legal abortion mortality and general anesthesia. Atrash HK, Cheek TG, Hogue CJR. *American Journal of Obstetrics and Gynecology* 1988; **158:** 420.

A pharmacologic approach to the infusion of ritodrine. Caritis SN. *American Journal of Obstetrics and Gynecology* 1988; **158:** 380.

The effect of vasopressor agents upon uterine artery blood flow velocity in the gravid guinea pig subjected to ritodrine infusion. Chestnut DH, Ostman LG *et al. Anesthesiology* 1988; **68:** 363.

Serial evaluation of vasopressin release and thirst in human pregnancy. Role of human chorionic gonadotrophin in the osmoregulatory changes of gestation. Davison JM, Shiells EA *et al. Journal of Clinical Investigation* 1988; **81:** 798.

Commentary: oxytocin and parturition—new complications. Dyer RG. *Journal of Endocrinology* 1988; **116:** 167.

Patient-controlled analgesia following cesarean section: a comparision with epidural and intramuscular narcotics. Eisenach JC, Grice SC, Dewan DM. *Anesthesiology* 1988; **68:** 444.

Long-term changes in medication during pregnancy. Harjulehto T, Aro T, Saxen L. *Teratology* 1988; **37:** 145.

Reduction or cessation of fetal movements after administration of steroids for enhancement of lung maturation. 1. Clinical evaluation. Katz M, Meizner I *et al. Israel Journal of Medical Sciences* 1988; **24:** 5.

A single dose epidural technique for caesarean section. Laishley RS, Morgan BM. *Anaesthesia* 1988; **43:** 100.

Subarachnoid anaesthesia for elective caesarean section. Michie AR, Freeman RM *et al. Anaesthesia* 1988; **43:** 96.

Epidural versus combined spinal epidural block for cesarean section. Rawal N, Schollin J, Wesstrom G. *Acta Anaesthesiologica Scandinavica* 1988; **32:** 67.

Epidural sufentanil for postoperative analgesia after cesarean section. Rosen MA, Dailey PA *et al. Anesthesiology* 1988; **68:** 448.

Assessment of fetal risk in postdate pregnancies. Usher RH, Boyd ME *et al. American Journal of Obstetrics and Gynecology* 1988; **158:** 259.

Paediatric anaesthesia and intensive care

EEG and brain death determination in children. Alvarez LA, Moshe SL *et al. Neurology* 1988; **38:** 227.

Effect of distal endotracheal bias flow on $Pa\text{CO}_2$ during high frequency oscillatory ventilation. Bancalari A, Bancalari E *et al. Biology of the Neonate* 1988; **53:** 61.

Prenatal alcohol exposure and offspring hyperactivity: effects of physostigmine and neostigmine. Bond NW. *Neurotoxicology and Teratology* 1988; **10:** 59.

The role of carbon dioxide in the generation of human fetal breathing movements. Connors G, Hunse C *et al. American Journal of Obstetrics and Gynecology* 1988; **158:** 322.

Paediatric postoperative analgesia. Fell D, Derrington MC *et al. Anaesthesia* 1988; **43:** 107.

New brain death guidelines in children— further confusion. Freeman JM, Ferry PC. *Pediatrics* 1988; **81:** 301.

Fetal heart rate and activity patterns in growth-retarded fetuses: changes after vibratory acoustic stimulation. Gagnon R, Hunse C *et al. American Journal of Obstetrics and Gynecology* 1988; **158:** 265.

Concentrations of human atrial natriuretic peptide in the cord blood and the plasma of the newborn. Ito Y, Matsumoto T *et al. Acta Paediatrica Scandinavica* 1988; **77:** 76.

Increase in intragastric pressure during suxamethonium-induced muscle fasciculations in children—inhibition by alfentanil. Lindgren L, Saarnivaara L. *British Journal of Anaesthesia* 1988; **60:** 176.

Prediction of nonsurvival in critically ill infants with respiratory failure. Marx G. *American Journal of Diseases of Children* 1988; **142:** 261.

Pharmacokinetics of bupivacaine following caudal anesthesia in infants. Mazoit JV, Denson DD, Samii K. *Anesthesiology* 1988; **68:** 387.

Comparison of atracurium-induced neuromuscular blockade in neonates, infants, and children. Meakin G, Shaw EA *et al. British Journal of Anaesthesia* 1988; **60:** 171.

Maturation of the lower oesophageal sphincter in the preterm baby. Newell SJ, Sarkar PK *et al. Gut* 1988; **29:** 167.

Abnormal pulmonary aeration in infants and the children. Newman B, Oh KS. *Radiologic Clinics of North America* 1988; **26:** 323.

Adult respiratory distress syndrome in pediatric patients. 1. Clinical aspects, pathophysiology, pathology, and mechanisms of lung injury. Royall JA, Levin DL. *Journal of Pediatrics* 1988; **112:** 169.

Upper airway and tracheal obstruction in infants and children. Strife JL. *Radiologic Clinics of North America* 1988; **26:** 309.

Tracheal and bronchial injury in high-frequency oscillatory ventilation and high-frequency flow interruption compared with postive-pressure ventilation Wiswell TE, Clark RH *et al. Journal of Pediatrics* 1988; **112:** 249.

Cardiovascular system

Physiology

Pulsus paradoxus: definition and relation to the severity of cardiac tamponade. Curtiss EI, Reddy PS *et al. American Heart Journal* 1988; **115:** 391.

Assessment of myocardial oxidative stress in patients after myocardial revascularization. Ferreira R, Llesuy S *et al. American Heart Journal* 1988; **115:** 307.

Cardiovascular effects of intravenous and intracoronary administration of atrial natriuretic peptide in halothane anesthetized dogs. Iwanaga R, Hori S *et al. Life Sciences* 1988; **42:** 1279.

Pathophysiology and clinical aspects of fibrinolysis and inhibition of coagulation. Jespersen J. *Danish Medical Bulletin* 1988; **35:** 1.

The pathology and etiology of cocaine-induced heart disease. Karch SB, Billingham ME. *Archives of Pathology and Laboratory Medicine* 1988; **112:** 225.

Mechanisms mediating the heart rate response to hypoxemia. Kato H, Menon AS, Slutsky AS. *Circulation* 1988; **77:** 407.

The links between basic and clinical cardiac electrophysiology. Rosen MR. *Circulation* 1988; **77:** 251.

Renal effects of atrial natriuretic factor during control of the renin-angiotensin system in anesthetized dogs. Seymour AA, Mazack EK. *Circulation Research* 1988; **62:** 506.

Cardiac output-changes during hemodialysis with ultrafiltration. Vandenbogaerde JF, Vanholder RC *et al. Clinical Nephrology* 1988; **29:** 88.

Dynorphin peptide induces hypotension by stimulating the release of atrial natriuretic peptide from rat atrium. Xie CW, Yin LY *et al. Life Sciences* 1988; **42:** 1117.

Treatment and medication

Effect of intravenous APSAC on mortality after acute myocardial infarction: preliminary report of a placebo-controlled clinical trial. Aims Trial Study Group, Chamberlain DA. *Lancet* 1988; **1:** 545.

Effects of hemodialysis on platelets. Andrassy K, Ritz E, Bommer J. In: Koch KM, Streicher E, eds. *Biological reactions within the extracorporeal blood circuit during hemodialysis.* Basel: S Karger, 1987: 26.

Antiarrhythmic activity, electrocardiographic effects and pharmacokinetics of encainide metabolites O-desmethyl encainide and 3-methoxy-O-desmethyl encainide in man. Barbey JT, Thompson KA *et al. Circulation* 1988; **77:** 380.

Physiologic mechanisms governing hemodynamic responses to positive inotropic therapy in patients with dilated cardiomyopathy. Borow KM, Lang RM *et al. Circulation* 1988; **77:** 625.

Theophylline intoxication caused by interaction with high-dose ranitidine. Dietemannmolard A, Popin E *at el. La Presse Medicale* 1988; **17:** 280.

Pharmacokinetics and haemodynamics of felodipine as monotherapy in hypertensive patients. Edgar B, Collste P *et al. Drugs* 1987; **34** (Suppl. 3): 28.

Comparative effects of antiarrhythmic drugs on the ventricular fibrillation threshold. Euler DE, Scanlon PJ. *Journal of Cardiovascular Pharmacology* 1988; **11:** 291.

End-tidal carbon dioxide concentration during cardiopulmonary resuscitation. Falk JL, Rackow EC, Weil MH. *New England Journal of Medicine* 1988; **318:** 607.

Preoperative aspirin ingestion increases operative blood loss after coronary artery bypass grafting. Ferraris VA, Ferraris SP *et al. Annals of Thoracic Surgery* 1988; **45:** 71.

High-dose furosemide in the treatment of refractory congestive heart failure. Gerlag PGG, Vanmeijel JJM. *Archives of Internal Medicine* 1988; **148:** 286.

Managing critically ill patients with esmolol—an ultra short-acting beta-adrenergic blocker. Gray RJ. *Chest* 1988; **93:** 398.

The protection of ischemic lung with verapamil and hydralazine. Hachida M, Morton DL. *Journal of Thoracic and Cardiovascular Surgery* 1988; **95:** 178.

Metabolism of (14C) felodipine, a new vasodilating drug, in healthy volunteers. Hoffmann KJ, Anderson L. *Drugs* 1987; **34** (Suppl. 3): 43.

Preservation of myocardial high energy phosphates during cardioplegic arrest with nifedipine. Ip JH, Levett JM *et al. Journal of Surgical Research* 1988; **44:** 216.

Effects of the calcium antagonist felodipine on the sympathetic and renin-angiotensin-aldosterone systems in essential hypertension. Katzman PL, Hulthen UL, Hokfelt B. *Acta Medica Scandinavica* 1988; **223:** 125.

Changes in atrial natriuretic factor during preload reduction with nitroglycerin in patients with congestive heart failure. Keller N, Sykulski R *et al. Clinical Physiology* 1988; **8:** 57.

Transcutaneous oxygen tension in patients with post-thrombolic leg ulcers—treatment with intermittent pneumatic compression. Kolari PJ, Pekanmaki K, Pohjola RT. *Cardiovascular Research* 1988; **22:** 138.

Cardiovascular effects of n-3 fatty acids. Leaf A, Weber PC. *New England Journal of Medicine* 1988; **318:** 549.

Transcutaneous oxygen measurements in lower extremity ischemia—effects of position, oxygen inhalation, and arterial reconstruction. Moosa HH, Peitzman AB *et al. Surgery* 1988; **103:** 193.

Multivessel coronary spasm in patients with variant angina—a study with intracoronary injection of acetylcholine. Okumura K, Yasue H *et al. Circulation* 1988; **77:** 535.

Antiarrhythmic and arrhythmogenic actions of methyl lidocaine during the recovery phase after canine myocardial infarction. Patterson E, Gibson JK, Lucchesi BR. *Pharmacology* 1988; **36:** 73.

Anticoagulation: a surgical perspective. Perry MO. *American Journal of Surgery* 1988; **155:** 268.

Assessment of LV function, coronary hemodynamics and catecholamine balance in severe congestive heart failure after a single oral dose of milrinone. Piscione F, Jaski BE, Serruys PW. *Journal of Cardiovascular Pharmacology* 1988; **11:** 258.

The effects of slow channel blockers and beta blockers on atrioventricular nodal conduction. Prystowsky EN. *Journal of Clinical Pharmacology* 1988; **28:** 6.

Postdilution hemofiltration in the management of acute hepatic failure: a pilot study. Rakela J, Kurtz SB *et al. Mayo Clinic Proceedings* 1988; **63:** 113.

Pharmacokinetics of felodipine and effect on digoxin plasma levels in patients with heart failure. Rehnqvist N, Billing E *et al. Drugs* 1987; **34** (Suppl. 3): 33.

Low dose infusions of 26- and 28-amino acid human atrial natriuretic peptides in normal man. Richards AM, Tonolo G *et al. Journal of Clinical Endocrinology and Metabolism* 1988; **66:** 465.

Low molecular weight heparin compared with unfractionated heparin in prevention of postoperative thrombosis. Samama M, Bernard P *et al. British Journal of Surgery* 1988; **75:** 128.

Comparison of myoglobin and creatine kinase MB levels in the evaluation of myocardial injury after cardiac operations. Seguin J, Saussine M *et al. Journal of Thoracic and Cardiovascular Surgery* 1988; **95:** 294.

Nifedipine enhances the vasodepressor and natriuretic effects of atrial natriuretic peptide. Seino M, Abe K *et al. Hypertension* 1988; **11:** 34.

Acute complications of elective coronary angioplasty: a review of 500 consecutive procedures. Steffenino G, Meier B *et al. British Heart Journal* 1988; **59:** 151.

Ischemic myocardial protection—comparison of nonoxygenated crystalloid, oxygenated crystalloid, and oxygenated fluorocarbon cardioplegic solutions. Tabayashi K, McKeown PP *et al. Journal of Thoracic and Cardiovascular Surgery* 1988; **95:** 239.

Prenalterol in severe congestive heart failure. II. Long-term oral treatment. Results on the evaluation of drugs in congestive heart failure. Tango M, Lyngborg K *et al. Danish Medical Bulletin* 1988; **35:** 78.

Prenalterol in severe congestive heart failure. I. The immediate haemodynamic effects as compared to nitroglycerine. Tango M, Trap-Jensen J *et al. Danish Medical Bulletin* 1988; **35:** 75.

Loss of the somatosensory evoked response as an indicator of reversible cerebral ischemia during hypothermic, low-flow cardiopulmonary bypass. Wilson GJ, Rebeyka IM *et al. Annals of Thoracic Surgery* 1988; **45:** 206.

Enalapril and atenolol in essential hypertension: attenuation of hypotensive effects in combination. Wing LMH, Chalmers JP *et al. Clinical and Experimental Hypertension* 1988; **10:** 119.

Intravenous fenoldopam in heart failure: comparing the hemodynamic effects of dopamine, receptor agonism with nitroprusside. Young JB, Leon CA *et al. American Heart Journal* 1988; **115:** 378.

Respiration

Physiology

Relationship of alveolar epithelial injury and repair to the induction of pulmonary fibrosis. Adamson IYR, Young L, Bowden DH. *American Journal of Pathology* 1988; **130:** 377.

Cellular mechanisms of airway secretion. Basbaum C, Carlson D *et al. American Review of Respiratory Disease* 1988; **137:** 479.

Pulmonary epithelial permeability in bronchiectasis. Chan TB, Arm JP, Anderson J. *British Journal of Diseases of the Chest* 1988; **82:** 56.

Recent advances in understanding the pathogenesis of asthma and its clinical implications. Holgate ST, Finnerty JP. *Quarterly Journal of Medicine* 1988; **66:** 5.

Improvement of diaphragmatic function by a thoracic extradural block after upper abdominal surgery. Mankikian B, Cantineau JP *et al. Anesthesiology* 1988; **68:** 379.

Thoracic gas volume measurements in chronic obstructive pulmonary disease by low frequency ambient pressure changes. Peslin R, Hannhart B *et al. American Review of Respiratory Disease* 1988; **137:** 277.

Measurements of oxygen pressure in the vocal fold during laryngeal nerve stimulation. Tomita M, Matsuo K *et al. Archives of Otolaryngology—Head, Neck Surgery* 1988; **114:** 308.

Autoradiographic visualization of muscarinic receptors in human bronchi. Vankoppen CJ, Blankesteinjn WM *et al. Journal of Pharmacology and Experimental Therapeutics* 1988; **244:** 760.

A pathophysiological study of 10 cases of hypoxic cor pulmonale. Wilkinson M, Langhorne CA *et al. Quarterly Journal of Medicine* 1988; **66:** 65.

Ventilation and breathlessness on maximal exercise in patients with interstitial lung disease after local anaesthetic acrosol inhalation. Winning AJ, Hamilton RD, Guz A. *Clinical Science* 1988; **74:** 275.

Treatment and medication

The utility of a long-acting sympathomimetic agent, procaterol, for nocturnal asthma. Baughman RP, Loudon RG. *Chest* 1988; **93:** 285.

Humidifier lung and humidifier fever. Baur X, Behr J *et al. Lung* 1988; **166:** 113.

A hazard of pressure support ventilation. Black JW, Grover BS. *Chest* 1988; **93:** 333.

Getting a patient off the ventilator. Branthwaite MA. *British Journal of Diseases of the Chest* 1988; **82:** 16.

Subjective effects of humidification of oxygen for delivery by nasal cannula—a prospective study. Campbell EJ, Baker MD, Critessilver P. *Chest* 1988; **93:** 289.

New advances in diagnosing nosocomial pneumonia in intubated patients. 1. Faling LJ. *American Journal of Respiratory Disease* 1988; **137:** 253.

Chronic obstructive lung disease prevention. Holland WW. *British Journal of Diseases of the Chest* 1988; **82:** 32.

Therapy with nifedipine in asthma—randomized double-blind crossover trial. Lidji M, Molho M *et al. Israel Journal of Medical Sciences* 1988; **24:** 1.

Aminophylline treatment in severe, acute asthma. Littenberg B. *Journal of the American Medical Association* 1988; **259:** 1678.

Bronchoalveloar lavage sampling of airway and alveolar cells. Robinson BWS, James A *et al. British Journal of Diseases of the Chest* 1988; **82:** 45.

Subcutaneous apomorphine in Parkinsonian on-off oscillations. Stibe CMH, Lees AJ *et al. Lancet* 1988; **1:** 403.

Phrenic nerve function in patients with diaphragmatic weakness and systemic lupus erythematosus. Wilcox PG, Stein HB *et al. Chest* 1988; **93:** 352.

Central nervous system

Physiology

Imaging of the aging brain. 1. Normal findings. Drayer BP. *Radiology* 1988; **166:** 785.

Imaging of the aging brain. 2. Pathologic conditions. Drayer BP. *Radiology* 1988; **166:** 797.

Pharmacological considerations on sleep mechanisms. Gaillard JM, Kafidesthilaire S, Blois R. In: Sauvanet JP *et al.*, eds. *Imidazopyridines in sleep disorders*. New York: Raven Press, 1988: 71.

Sleep apnea and body position during sleep. George CF, Millar TW, Kryger MH. *Sleep* 1988; **11:** 90.

Autonomic nervous function in Huntington's disease. Heijer JCD, Bollen WLEM *et al. Archives of Neurology* 1899; **45:** 309.

Disconnection and cerebral metabolism: the case of conduction aphasia. Kempler D, Metter EJ *et al. Archives of Neurology* 1988; **45:** 275.

Familial sleep apnea plus syndrome—report of a family. Manonespaillat R, Gothe B *et al. Neurology* 1988; **38:** 190.

Effect of aging on the blood-brain barrier. Mooradian AD. *Neurobiology of Aging* 1988; **9:** 31.

Minireview: Cocaine and central monoaminergic neurotransmission: a review of electrophysiological studies and comparison to amphetamine and antidepressants. Pitts DK, Marwah J. *Life Sciences* 1988; **42:** 949.

Differential effects after repeated treatment with haloperidol, clozapine, thioridazine and tefludazine on SNC and VTA dopamine neurones in rats. Skarsfeldt T. *Life Sciences* 1988; **42:** 1037.

Mechanisms of mania after brain injury—12 case reports and review of the literature. Starkstein SE, Boston JD, Robinson RG. *Journal of Nervous and Mental Disease* 1988; **176:** 87.

Treatment and medication

Diagnosis and treatment of aphasia: part 1. Albert ML, Helm-Estabrooks N. *Journal of the American Medical Association* 1988; **259:** 1043.

Use of etomidate, temporary arterial occlusion, and intraoperative angiography in surgical treatment of large and giant cerebral aneurysms. Batjer HH, Frankfurt AI *et al. Journal of Neurosurgery* 1988; **68:** 234.

The role of vasopressin in acute cerebral vasospasm—effect on spasm of a vasopressin antagonist or vasopressin antiserum. Delgado TJ, Arbab MAR *et al. Journal of Neurosurgery* 1988; **68:** 266.

Transport of amantadine and rimantadine through the blood-brain barrier. Spector R. *Journal of Pharmacology and Experimental Therapeutics* 1988; **244:** 516.

Endocrine and metabolic

Physiology

Opioid peptides do not modulate atrial natriuretic peptide or aldosterone release under basal conditions in man. Borges F, Anderson JV *et al., Journal of Endocrinology* 1988; **116:** 313.

The central effects of the renin-angiotensin system. Buckley JP. *Clinical and Experimental Hypertension* 1988; **10:** 1.

Sorbitol, osmoregulation, and the complications of diabetes. Burg MB, Kador PF. *Journal of Clinical Investigation* 1988; **81:** 635.

The pharmacology of potassium channels and their therapeutic potential. Cook NS. *Trends in Pharmacological Sciences* 1988; **9:** 21.

Reduced concentrations of potassium, magnesium, and sodium-potassium pumps in human skeletal muscle during treatment with diuretics. Dorup I, Skajaa K *et al. British Medical Journal* 1988; **296:** 455.

Acidosis, hypoxia and stress hormone release in response to one-minute inhalation of 80% CO2 in swine. Forslid A, Augustinsson O. *Acta Physiologica Scandinavica* 1988; **132:** 223.

The acute renal haemodynamic and endocrine response to felodipine in normal man. Jenkins DAS, Craig K *et al. European Journal of Clinical Pharmacology* 1988; **33:** 581.

Effect of opiate, general anaesthesia and surgery on plasma atrial natriuretic peptide levels in man. Kidd JE, Gilchrist NL *et al. Clinical and Experimental Pharmacology and Physiology* 1987; **14:** 755.

Role of antidiuretic hormone in the attenuated furosemide response observed during indomethacin administration. Kirchner KA. *Journal of Laboratory and Clinical Medicine* 1988; **111:** 237.

Synthesis of arginine-vasopressin. Modified in positions 1 and 2, as antagonists of the vasopressor response to the parent hormone. Lammek B, Rekowski P *et al. Journal of Medicinal Chemistry* 1988; **31:** 603.

Endocytosis of the vasopressin receptor by anterior pituitary cells is increased by corticotropin-releasing factor (CRF). Mogensen N, Saermark T, Vilhardt H. *Regulatory Peptides* 1988; **20:** 223.

Sympathetic skin response in diabetic peripheral neuropathy. Niakin E, Harati Y. *Muscle and Nerve* 1988; **11:** 261.

Preventive action of phentolamine on adrenaline induced blood glucose elevation in humans. Porta S, Hofmann HMH *et al. Acta Endocrinologica* 1988; **117:** 166.

Vasopressin stimulation of ACTH in humans. In vivo bioassay of CRF which provides evidence for CRF mediation of the diurnal rhythm of ACTH. Salata RA, Jarrett DB *et al. Journal of Clinical Investigation* 1988; **81:** 766.

Reflex sympathetic dystrophy syndrome coincident with acute diabetic neuropathy. Schapira D, Barron SA *et al. Journal of Rheumatology* 1988; **15:** 120.

Aldosterone response to metoclopramide is mediated through the autonomic nervous system in man. Sommers DK, Meyer EC *et al. European Journal of Clinical Pharmacology* 1988; **33:** 609.

Treatment and medication

The use of the urinary anion gap in the diagnosis of hyperchloremic metabolic acidosis. Batlle DC, Hizon M *et al. New England Journal of Medicine* 1988; **318:** 594.

The pathogenesis and prevention of diabetic neuropathy and nephropathy. Green D. *Metabolism* 1988; **37**(Suppl. 1): 25.

Studies of insulin resistance following hypoglycemia in insulin-dependent diabetes mellitus. Kollind M, Adamson U, Lins PE. *Acta Medica Scandinavica* 1988; **223:** 153.

Postoperative positive nitrogen balance with intravenous hyponutrition and growth hormone. Ponting GA, Halliday D *et al. Lancet* 1988; **1:** 438.

Inhibition of cyclo-oxygenase attenuates the metabolic response to endotoxin in humans. Revhaug A, Michie HR *et al. Archives of Surgery* 1988; **123:** 162.

Clinical benefits and mechanisms of a sustained response to intermittent insulin therapy in type 2 diabetic patients with secondary drug failure. Yki-Jarvinen H, Esko N *et al. American Journal of Medicine* 1988; **84:** 185.

Pain

Treatment and medication

Naproxen sodium versus acetaminophen-codeine for pain following plastic surgery. Busquets MAV, Keoshian LA *et al. Current Therapeutic Research* 1988; **43:** 311.

Other

Treatment and medication

Ocular and cardiovascular response to topical carteolol 2-percent and timolol 0.5-percent in healthy volunteers. Brazier DJ, Smith SE. *British Journal of Ophthalmology* 1988; **72:** 101.

Epidural spinal cord electrical stimulation improves microvascular blood flow in severe limb ischemia. Jacobs MJHM, Jorning PJG *et al. Annals of Surgery* 1988; **207:** 179.

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Obituaries

Bradbeer, Ernest Gustave, MRCS, LRCP, FFARCS, DA, formerly Consultant Anaesthetist to the United Bristol Hospitals. Qualified from Bristol University in 1923.

Nicholson, John Campbell, MB, ChB, formerly head of the Department of Anaesthesia in the University of Witwatersrand in Johannesburg. Qualified from University of Manchester in 1930.

International congress calendar

1988

4 September. Malta. *VI Annual Meeting of Association of Maltese Anaesthetists.*
Information: Dr N. Azzopardi, P.O. Box 15, Msida, Malta.

6–9 September. Rotterdam. *International Symposium on Computer-Assisted Decision Support and Data Base Management in Anesthesia, Intensive Care and Cardiopulmonary Medicine.*
Information: Dr O. Prakash, Erasmus University, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands.

7–10 September. Rome. *10th Annual Meeting of the European Academy of Anaesthesiology.*
Information: EAA Secretariat, Istituto Anestesiologia, Univ. Cattolica S. Cuore, Largo A Gemelli 8, 00186 Rome, Italy.

10–14 September. Florence. *3rd International Symposium.*
Information: Professor M. Zoppi, Cespri Fondazione Pro Juventute, Via Imprunetana 124, 500200 Monteriolo, Florence, Italy.

14–17 September. Brussels. *5th International Congress.*
Information: Professor F. Camu, AZ.VU, Laarbeeklaan 101, B-1090 Brussels, Belgium.

14–16 September. Cambridge. *Royal College of Surgeons Annual Meeting.*
Information: The Royal College of Surgeons, Lincoln's Inn Fields, London WC2.

14–16 September. Southampton. *Linkman Conference and Annual Scientific Meeting and Exhibition.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London WC1B 3RA.

19–21 September. Brussels. *European Course on Paediatric Anaesthesia.*
Information: A.S.M., Avenue de L'Hippodrome, 31, B 1050, Brussels, Belgium.

1 October. Pavia. *National Congress Societa Italiana di Anest, Rianimazione e Terapia Intensiva.*
Information: Dr G. Conti, SIARRTI, Universita degli Studi, La Sapienza di Roma, Viale del Policlinico, 00161 Roma, Italy.

6–9 October. Belgrade *Anglo-Serbian Days of Anaesthesia.*
Information: Professor Dr D. Vucovic, Macvanska 8, 11000 Beograd, Yugoslavia.

8–12 October. San Francisco. *Annual Meeting of the American Society of Anesthesiologists.*
Information: John W. Andes, Executive Secretary, 515 Busse Highway, Park Ridge, Illinois 60068, USA.

13–15 October. Mainz, Federal Republic of Germany. *7th Annual Meeting of the European Society of Regional Anaesthesia.*
Information: Klinikum fur Anasthesiologie, Postfach 3960, Langenbeckstrasse 1, 6500 Mainz, Federal Republic of Germany.

23–28 October. Rio de Janeiro. *World Congress of Gynecology and Obstetrics.*
Information: Professor Paulo Belfort, Av. Armando Lombardi, 800/223 Barra da Tijuca, 22600 Rio de Janeiro RJ, Brazil.

29 October–2 November. Ballarat, Victoria. *Annual General Meeting Australian Society of Anaesthetists.*
Information: The Secretariat, ASA, P.O. Box 600, Edgecliff, New South Wales 2027, Australia.

9–12 November. Tauranga, New Zealand. *Conference of Anaesthetists of New Zealand.*
Information: Dr M. Hugel, Conference Secretary, Department of Anaesthetics, Tauranga Hospital, Private Bag, Tauranga, New Zealand.

22–26 November. Trieste, Italy. *3rd Postgraduate Course on Recent Advances in Anaesthesia, Pain, Intensive Care and Emergency.*
Information: Organizing Secretariat, Trieste Traduzioni Congressi, V.le XX Settembre 4, 34125 Trieste, Italy.

27 November–2 December. Belem, Para, Brazil. *XXXV Brazilian Congress of Anaesthesiology.*
Information: Congress Secretariat, Dr Rui Silva Ventura, 66030, Tv. Piedade 469/104, Belem, Para, Brazil.

17–24 December. Colorado. *Current Issues in Medicine.*
Information: Professional Seminars/University of Miami, P.O. Box 012318, Miami, Florida 33101.

27–30 December. Udaipur, India. *XXXVII Annual Conference of the Indian Society of Anaesthetists.*
Information: Organising Secretary, 25 Ololground, Udaipur, 313001, India.

1989

13–14 January. London. *Winter Scientific Meeting, Association of Anaesthetists of Great Britain and Ireland.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1 39A.

14–21 January. Puerto Vallarta, Mexico. *7th Annual Symposium of the Mount Sinai Medical Center on Clinical Update in Anesthesiology.*
Information: Helen Phillips, Mount Sinai Medical Center, 1 Gustave L. Levy Place, Box 1010, New York, NY 10029.

7–12 May. Melbourne, Australia. *Faculty of Anaesthetists and the Royal Australasian College of Surgeons Annual General Meeting.*
Information: Administrative Officer, Faculty of Anaesthetists, RACS, Spring Street, Melbourne, Victoria 3000.

11–14 May. Rotterdam. *Second European Congress of Paediatric Anaesthesia.*
Information: Mrs J.F. Aukes-Jager, Sophia Children's Hospital, Department of Paediatric Anaesthesia, Gordelweg 160, NL-3038 GE Rotterdam.

17–19 May. Lisbon. *VIII Annual Meeting of the European Society of Regional Anaesthesia.*
Information: Dr E. Lopes Soares, Rua Cidade de Cadiz 14, 1500 Lisboa.

9–13 June. Ottawa. *Joint Meeting of the Canadian Anaesthetists' Society with the Association of Anaesthetists of Great Britain and Ireland.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London WC1B 3RA.

26–30 June. Copenhagen. *20th Scandinavian Congress.*
Information: Professor S.H. Johansen, Herlev Hospital, DK 2730 Herlev, Denmark.

12–16 August. Christchurch, New Zealand. *Combined Meeting New Zealand Society of Anaesthetists and Australian Society of Anaesthetists.*
Information: ASA, Box 600, Edgecliff, NSW 2027, Australia.

3–8 September. Kyoto, Japan. *5th World Congress on Intensive and Critical Care Medicine.*
Information: The 5th World Congress on Intensive and Critical Care Medicine, c/o Japan Convention Services Inc., Nippon Press Center Building, 2-2-1 Uchisaiwai-cho, Chiyoda-ku, Tokyo 100, Japan.

10–14 September. Freiburg. *8th Congress of European Society of Pneumology.*
Information: Professor Dr med. H. Matthys, Arztlicher Direktor, Abteilung Pneumologie, Robert-Koch-Klinik, Universitat, D 7800 Freiburg, West Germany.

12–16 September. Austria. *International Conference on Anaesthesia, Intensive Care and Emergency Medicine.*
Information: Professor Doctor J.M. Hackl, University Klinik fur Anaesthesie und Allg. Intensivmedizin, Anichstr. 35, A-6020 Innsbruck, Austria.

14–15 September. Osaka, Japan. *4th International Symposium of Endocrinology in Anaesthesia and Surgery.*
Information: Department of Anesthesiology, University of Hirosaki, School of Medicine, 5 Zaifu-cho, Hirosaki, Aomori-ken, 036 Japan.

18–22 September. London. *9th Congress of the Federation Internationale de Medecine Manuelle.*
Information: Conference Associates FIMM, 27A Medway Street, London, SW1P 2BD.

18–20 October. Barcelona. *11 Congress of Chronical Roncopathy.*
Information: BRP, Edificio Layetana C/Pau Claris, 138, 08009 Barcelona.

4–7 October. Tunis. *3rd Pan Arab Congress on Anaesthesia and Intensive Care.*
Information: Secretary, P.O. Box 15404, Marka, Amman, Jordan.

5–10 November. Sao Paulo. *36th Brazilian Congress of Anesthesiology.*
Information: Congress Secretariat, Dr R.S. Nathias, Rua Caiubi 666, Sao Paulo, Brazil 05010.

1990

13–19 May. Wellington, New Zealand. *Faculty of Anaesthetics and the Royal Australasian College of Surgeons Annual General Meeting.*
Information: Administrative Officer, Faculty of Anaesthetists, RACS, Spring Street, Melbourne, Victoria 3000.

9–15 September. Warsaw. *VIIIth European Congress of Anaesthesiologie.*
Information: The Organising Committee, VIIIth European Congress of Anaesthesiology, c/o Polish Society of Anaesthesiology and Intensive Therapy, ul. Kasprzaka 17a, 01–211 Warsaw, Poland.

23–28 September. Seoul, Korea. *8th Asian/Australasian Congress of Anaesthesia.*
Information: Department of Anesthesiology, Seoul National University Hospital, 28 Yungun-Dong, Chongro-Ku, Seoul 110.

26–28 September. Manchester. *Linkman Conference and Annual Scientific Meeting and Exhibition.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London WC1B 3RA.

1992

29 March–2 April. Altanta, Georgia. *The 3rd International Symposium on the History of Anaesthesia.*
Information: R.K. Calverley, MD, Clinical Professor of Anesthesiology, Medical Center, University of California, 225 Dickinson Street, San Diego, California CA 92103-1990, USA.

14–19 June. The Hague. *10th World Congress of Anaesthesiology.*
Information: Dr Harm Lip, Nilantsweg 99, 8041 AR Zwolle, Netherlands.

1993

September. Edinburgh. *Joint Meeting with the Canadian Society of Anaesthetists.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London WC1B 3RA.

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......................19

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Association of Anaesthetists of Great Britain and Ireland

I (full name) .... offer my name as a candidate
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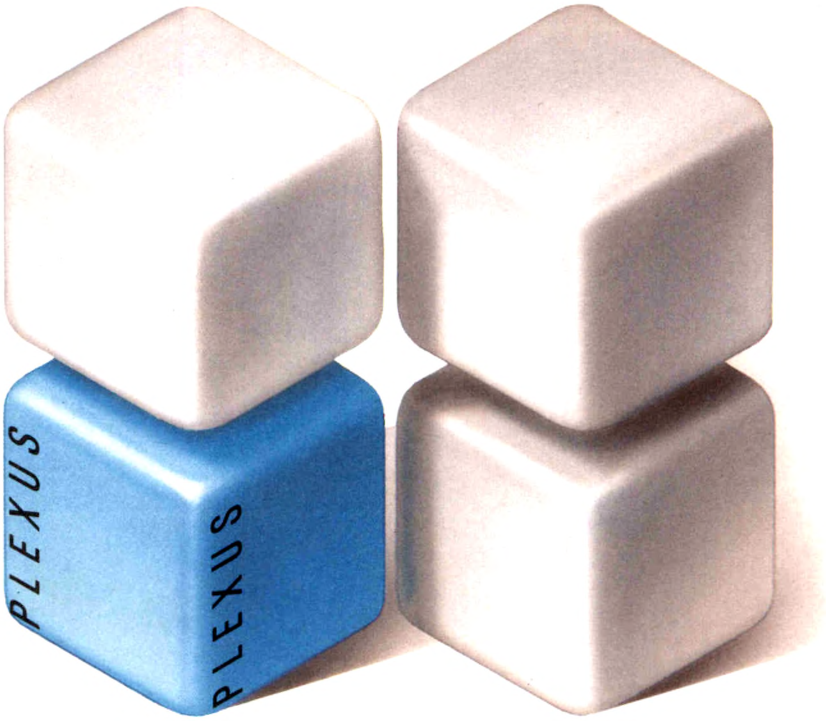

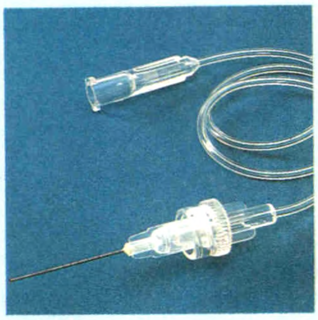

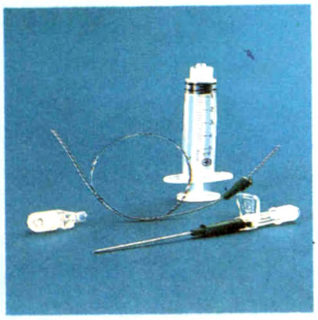

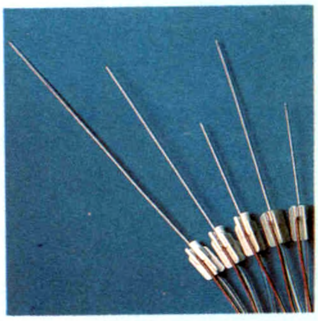

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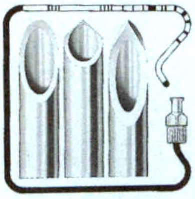

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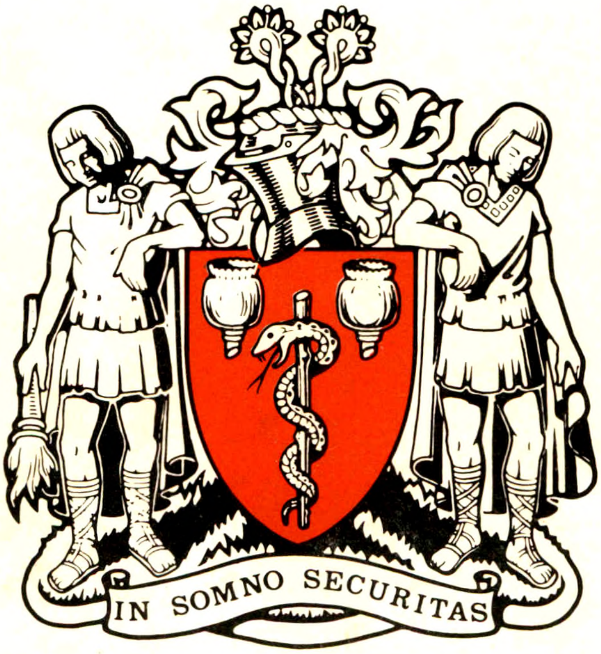

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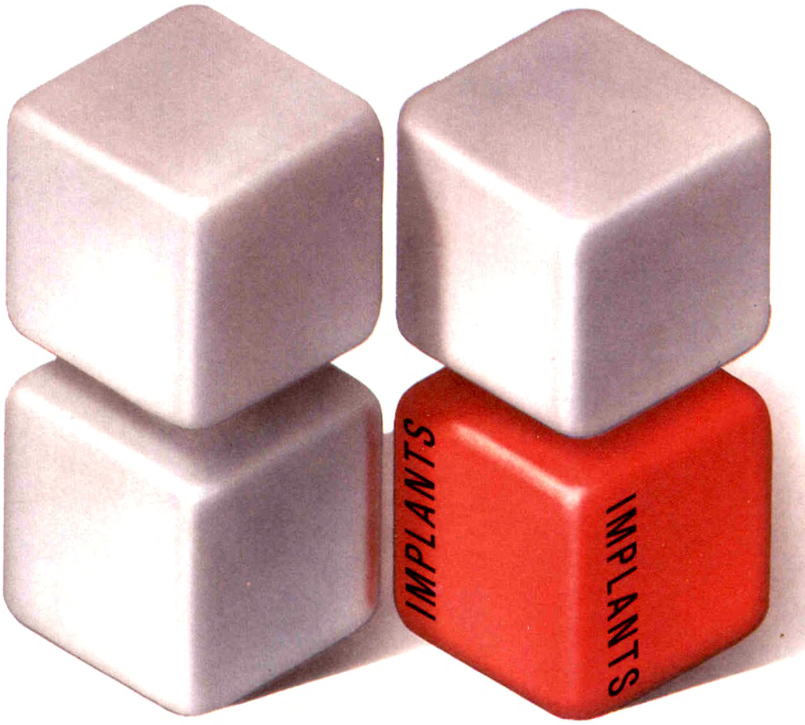

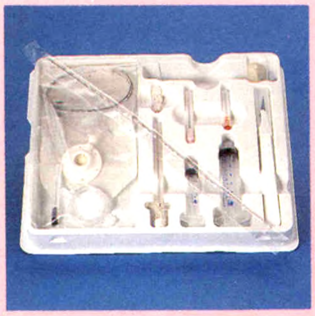

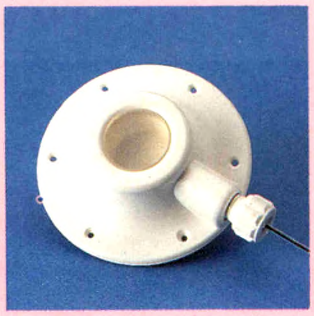

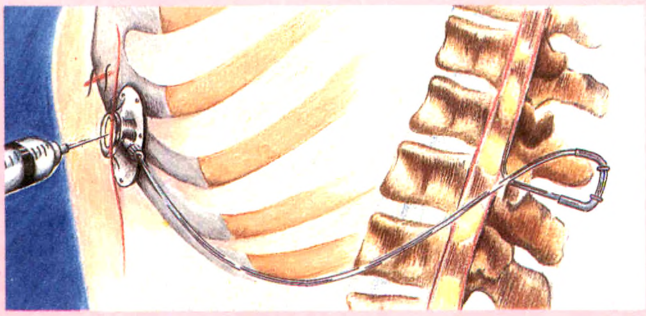

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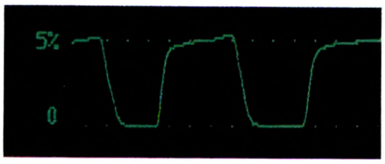

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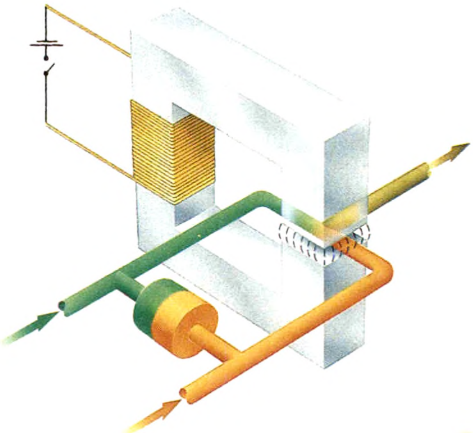

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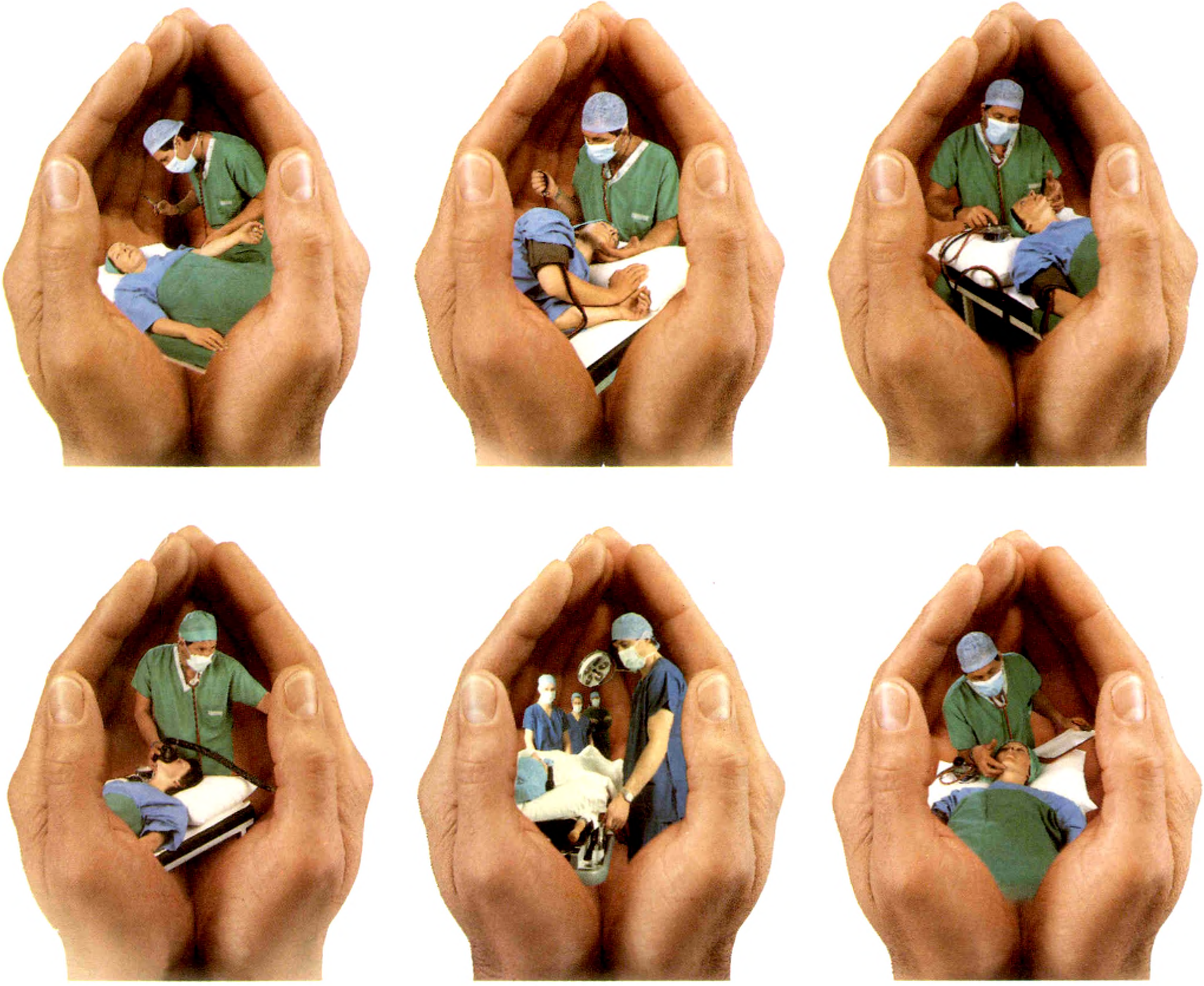

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Anaesthesia, 1988, Volume 43, pages 627–628

Editorial

Reporting adverse reactions to anaesthetic drugs: a new way forward

An adverse drug reaction (ADR) may be defined as the occurrence of any drug effect that is not of therapeutic, diagnostic or prophylactic benefit to the patient to whom the drug is given.[1] In anaesthesia, as in all branches of therapeutics and clinical pharmacology, it is important that the prescriber knows (or at least has rapid access to) accurate and contemporary data about the type and frequency of any possible adverse effects of the drug so that he might make a decision about selection for use on the basis of the totality of risk and benefit of a particular drug or regimen.

Classification of adverse drug reactions

The simple classification of ADRs into Type A and Type B reactions has the benefit of simplicity and it may help understanding.[2] Type A reactions are dose related, qualitatively normal responses to drugs. They are predictable, very common and usually a simple exaggeration of the normal drug effect. One is likely to see this type of reaction almost every day in the operating room (e.g. a period of apnoea after injection of propofol or thiopentone).

Type B reactions are usually more severe, unpredictable, unrelated to the drug's normal effects, not dose related and less common. They include specifically the manifestations of acute drug allergy and malignant hyperpyrexia. Anaesthetists are more likely to see these frightening reactions than other practitioners. Because of this risk, a National Anaesthetic Adverse Reaction Advisory Service (NAARAS) has been established in Sheffield[3] to assist doctors in the appropriate investigation of these ADRs.

Detection of ADRs

Premarketing volunteer and clinical trials may detect common Type A ADRs and may identify some subgroups at risk but their ability to predict rarer Type B reactions is limited as only a thousand or so patients are exposed. After marketing, published isolated case reports are a sensitive but not very specific way to detect ADRs. Cohort or comparative studies eliminate the bias of other types of reporting but must be large and therefore expensive to answer even one question. Retrospective case control studies may identify rarer reactions more quickly and cheaply but results are often inconsistent.

In the UK, the yellow card scheme provides a system whereby a doctor can report *suspected* adverse drug reactions to the Committee on Safety of Medicines (CSM). The CSM has a statutory obligation to promote the collection and investigation of information related to ADRs and it relies, to a large extent, on spontaneous reports on yellow cards. In 1989, the scheme will be 25 years old. The number of reports has increased from 1307 in 1964 to 16 431 in 1987 but the CSM continues to take active steps to increase the reporting rate. The yellow cards relate to suspected clinical associations only and the data are uncontrolled. Reporting is sometimes delayed and imprecise but the greatest disadvantage is the degree of under-reporting. Reports reach a peak within a year or so of marketing and then fall off. Nevertheless, the scheme has provided important data on drug safety and toxicity.[2]

The yellow cards are reviewed rapidly by the CSM's Medical Secretariat. For new drugs, the latest anonymised data are discussed by a special subcommittee of the CSM each month. If it is considered necessary, the CSM communicates with the medical profession in one or more of three ways: *Current Problems,* a broadsheet mailed to all doctors about three times each year giving alerts of new ADR problems; a *Dear Doctor* letter to every medical practitioner advising on urgent safety issues (e.g. changed indications or drug withdrawal); *CSM Update* in the *British Medical Journal* which reviews yellow card data.[4] The CSM may advise Ministers that a drug should be withdrawn from the Market and it plays a key role in modifying manufacturer's data sheets as new safety information becomes available.

Anaesthetists were the first specialists to receive a letter of warning from the CSM, on 5 January 1974, 'Jaundice following repeated exposure to halothane'.[5] The CSM gave further advice about the use of halothane in *Current Problems* 18 dated September 1986. This controversy about the safety of halothane has not been clarified to the satisfaction of all and one of the undoubted problems is lack of data due to under-reporting of ADRs by anaesthetists. By 1986, the CSM had received some 150 000 yellow cards in total[6] of which approximately 2000 came from anaesthetists.[4] NAARAS receives some 100 reports of suspected Type B reactions alone per annum, so it is clear that the yellow card scheme has not been used by anaesthetists to the extent possible or desirable. The reasons for this were explored recently and a joint working party of the CSM, the Association of Anaesthetists of Great Britain and Ireland and the Faculty of Anaesthetists was formed to advise on how reporting ADRs might be improved.[4,5] The consensus view was that the yellow card was not the best design for reporting anaesthetic ADRs and that a new card was necessary.

The anaesthetic yellow card

A new anaesthetic yellow card has been designed and an example is enclosed with this issue of *Anaesthesia.* This card may

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be photocopied and used but further supplies are available as detailed below. From 1 September 1988, anaesthetists are asked to use this form to report adverse reactions to anaesthetic drugs. On completion the cards should be returned to the CSM directly.

What should be reported?

The recommendations about what should be reported are clear.[5,6] Doctors are asked to report, in respect of new drugs, any adverse or unexpected event, however minor, which could conceivably be attributed to the drug. New drugs are marked with an inverted black triangle in the *British National Formulary*, *MIMS* and the *Data Sheet Compendium*. For established drugs, doctors should report any suspected adverse drug reaction which is potentially dangerous, incapacitating or lethal. *These should be reported even if they are well recognised.* Anaesthetists are asked to report directly to the CSM even if they also tell the drug company or NAARAS of the ADR. If two anaesthetists are involved, it is important that they should agree which of them will report the ADR.

This scheme is a venture of the joint working party and the reports will be reviewed by the members after the cards have been made anonymous by the CSM. Reporting doctors may be sure that confidentiality will be maintained. Data will be reported to the specialty at regular intervals in some appropriate way and, at one year, the scheme will be reassessed.

Nothing can benefit the profession of anaesthesia more than having a large, valid database about adverse reactions to drugs. Only then will proper risk/benefit assessment be more available and difficult decisions about drug use be made with less controversy, entrenched opinion or speculation. It is hoped that the joint working party on behalf of its parent bodies may look forward to the support of anaesthetists in attempting to overcome the under-reporting of anaesthetic adverse drug reactions.

University of Sheffield,
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Sheffield S10 2RX

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References

1. GOLDBERG A. In: MANN RD, ed. *Adverse drug reactions*. Carnforth: Parthenon Publishing, 1987: 1–3.
2. BATEMAN DN, CHAPLIN S. Adverse reactions I. *British Medical Journal* 1988; **296:** 761–4.
3. WATKINS J. Adverse anaesthetic reactions. An update from a proposed national reporting and advisory service. *Anaesthesia* 1985; **40:** 797.
4. *CSM Update. British Medical Journal* 1986; **292:** 949.
5. DUNDEE JW. Adverse reactions to drugs and anaesthetists. Anaesthesia 1986; **41:** 351–352.
6. MANN RD. In: MANN RD, ed. *Adverse drug reactions*. Carnforth: Parthenon Publishing, 1987: 5–66.

ANNOUNCEMENT

The anaesthetic yellow card and the pilot scheme of its use are joint ventures of the Committee on Safety of Medicines, the Faculty of Anaesthetists and the Association of Anaesthetists of Great Britain and Ireland.

An example of the card is enclosed with this journal. Further supplies will be mailed to all anaesthetists in *Current Problems*, to hospital pharmacists and to Linkmen and Faculty tutors. Supplies may be obtained from these individuals or from the DHSS (Medicines Division), Market Towers, 1 Nine Elms Lane, London SW8 5NQ. Completed cards should be returned (Freepost) to this address.

For new drugs (marked by an inverted black triangle in the BNF, MIMS and the Data Sheet Compendium) please report *all* suspected adverse events, however minor, which might be attributable to the drug. For established drugs, please report *serious* suspected adverse reactions that are potentially dangerous, incapacitating or lethal even if they are well recognised. All reports will be treated as confidential but after being rendered anonymous, data will be analysed and reported.

Editorial notices

Anaesthesia News

Copy for *Anaesthesia News* should be sent to the Editor as and when it becomes available. It is hoped that publication will occur within 2 months of receipt.

Manuscripts must be submitted in accordance with the internationally recognised *Uniform requirements for manuscripts submitted to biochemical journals* (*British Medical Journal* 1979; **1:** 432 5). Details will be found in the Notice to Contributors to *Anaesthesia* at the end of this issue.

Anaesthesia, 1988, Volume 43, pages 629–632

Heart rate and arterial pressure changes during fibreoptic tracheal intubation under general anaesthesia

J. E. SMITH

Summary

The cardiovascular responses to fibreoptic orotracheal intubation under general anaesthesia were compared with those in a control group in whom tracheal intubation was effected with a Macintosh laryngoscope. The patients received a standard anaesthetic and were allocated randomly to either group immediately before intubation. Fibreoptic intubation took significantly longer to perform. There were significant increases in heart rate and arterial pressure in both groups compared with pre-induction values. The tachycardia in the fibreoptic group was significantly greater than that in the control group during the second minute after intubation, and the increase in systolic pressure was sustained for a longer period in the fibreoptic group. The maximum increases in systolic and diastolic pressures above pre-intubation values were significantly greater in the fibreoptic group. The cardiovascular responses associated with fibreoptic intubation under general anaesthesia appear to be more severe than those which follow intubation effected with a Macintosh laryngoscope.

Key words

Anaesthesia; general.
Intubation, tracheal; fibreoptic.

Fibreoptic assisted tracheal intubation was introduced into anaesthetic practice by Murphy in 1967[1] and Taylor and Towey in 1972.[2] Improved techniques have evolved[3–11] as experience and expertise with fibrescopes have increased, and fibreoptic endoscopy has come to occupy an important place in the management of the difficult intubation.[12] It is recognised that the conventional method of tracheal intubation, after laryngoscopy with a Macintosh laryngoscope, causes significant tachycardia and hypertension[13,14] as a result of activation of the sympathetic nervous system.[15,16] The pressor response to intubation has been associated with myocardial ischaemia,[17] cardiac failure,[18] intracranial haemorrhage[18] and other complications.[19,20] However, the cardiovascular effects of fibreoptic intubation have not been investigated.

The purpose of this study was to identify the changes in heart rate and arterial pressure during fibreoptic intubation under general anaesthesia, and to compare them with those in a control group of patients who received the same anaesthetic, but in whom tracheal intubation was undertaken in the conventional manner.

Patients and methods

The investigation was approved by the ethics committee of the South Birmingham Health Authority and informed written consent was obtained from each patient. Forty-three adult patients (ASA Class 1 or 2) who presented for elective general surgery and who required tracheal intubation, were studied. Patients with cardiovascular or neurological disease, and those taking vasoactive drugs of any kind, were excluded from the trial.

Patients were premedicated orally with lorazepam 0.05 mg/kg 2 hours before operation. Continuous ECG monitoring was established after arrival in the anaesthetic room. Arterial pressure and heart rate were recorded at one-minute intervals by a Dinamap 1846 automatic oscillometric blood pressure monitor and Dinamap 1900 printer. Control readings of arterial pressure and pulse rate were made after a stabilisation period of 5 minutes and anaesthesia was induced with a dose of thiopentone (4–5 mg/kg) sufficient to obtund the eyelash reflex, followed by alcuronium 0.3 mg/kg. The lungs were ventilated for 5 minutes with oxygen 33%, nitrous oxide 66% and halothane 0.5% by means of a pharyngeal airway and a face mask attached to a Bain system. Fresh gas flow and ventilation were adjusted to maintain the end expired carbon dioxide concentration at 5–5.5%, as measured by a Datex CD 300 capnograph using a sampling catheter placed under the mask.

Immediately before orotracheal intubation, each patient was allocated randomly either to the control group, in

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Table 1. Mean (SEM) values of pre-induction patient data in the two groups.

Group	Age, years	Weight, kg	Systolic arterial pressure, mmHg	Diastolic arterial pressure, mmHg	Heart rate, beats/minute
Fibreoptic	45.7 (3.6)	69.3 (2.9)	134 (4)	76 (3)	91 (3)
Control	50.8 (3.4)	73.0 (2.6)	133 (4)	76 (2)	85 (3)

Table 2. Time to achieve successful tracheal intubation.

Group	Number	Mean (SEM) time, seconds	Range, seconds
Fibreoptic	21	26.9 (1.9)	17–45
Control	20	9.6 (0.8)	5–17

whom tracheal intubation was effected using a Macintosh laryngoscope, or to the fibreoptic intubation group.

The fibreoptic intubations were carried out as described by Witton in 1981.[9] An LS–6A fibreoptic laryngoscope was focused and threaded through a tracheal tube. The patient's head rested on a single pillow. A trained assistant who stood on the patient's left side grasped the tongue with a gauze swab held in the left hand, and pulled it anteriorly away from the soft palate and posterior pharyngeal wall. The assistant's right hand was placed on the patient's occiput and the atlanto-occipital joint was extended. The tip of the fibreoptic laryngoscope was manipulated through the mouth into the pharynx under direct vision, with the dorsum of the tongue kept in view in the upper part of the visual field. It was then passed underneath the epiglottis, between the vocal cords and into the trachea. The tracheal tube was advanced over the laryngoscope into the trachea. The tube was rotated anticlockwise through approximately 90 degrees as it was advanced, so that the bevel came to lie in close contact with the anterior surface of the laryngoscope; this reduced the chance of the tip hooking on to either the vocal cords laterally or the arytenoids posteriorly. The position of the tube in the trachea above the carina was confirmed, the laryngoscope removed, the tube cuff inflated and ventilation started.

The intubation time was taken as the interval between removal of the face mask from the patient's face and reconnexion of the Bain system to the catheter mount after intubation had been completed. Any fibreoptic intubation which was not completed within 60 seconds was abandoned; the lungs were again ventilated and the tracheal tube was passed conventionally. The cardiovascular data from these patients were not included in the results. Values within and between groups were examined using the paired or unpaired Student's *t*-test as appropriate; $p < 0.05$ was considered to be significant.

Results

The two groups were similar with respect to age, weight, pre-induction arterial pressure and pulse rate (Table 1). Two of the 23 patients in the study group could not be intubated with the LS–6A fibreoptic laryngoscope within the 60 seconds allocated, although both were intubated easily after standard laryngoscopy. The mean time for intubation in the remaining 21 patients was 26.9 seconds; this was significantly longer than in the control group, (9.6 seconds; Table 2).

There was a significant increase in the mean heart rate after induction of anaesthesia in both groups compared to pre-induction values (Table 3). There was also a significant increase in mean heart rate after intubation in both groups compared with pre-intubation values. The greatest increase

Table 3. Mean (SEM) values of heart rate (beats/minute) in fibreoptic and control groups.

Group	Before induction	Before intubation	Time after intubation, minutes 1	2	3	4	5
Fibreoptic	91 (3)	103 (3)†	106 (4)†	109 (3)*†¶	105 (3)†	101 (3)†	98 (4)†
Control	85 (3)	99 (3)†	102 (4)†¶	101 (3)†	100 (3)†	97 (4)†	95 (4)†

† $p < 0.05$ compared to pre-induction values; ¶ $p < 0.05$ compared to pre-intubation values; * $p < 0.05$ compared to control values.

Table 4. Mean (SEM) values of arterial blood pressure (systolic and diastolic mmHg) in fibreoptic and control groups.

Group	Before induction	Before intubation	Time after intubation, minutes 1	2	3	4	5
Fibreoptic							
Systolic	134 (4)	120 (5)*	132 (5)	150 (4)*	143 (4)*	136 (3)	131 (3)
Diastolic	76 (3)	70 (3)*	89 (4)*	90 (3)*	84 (3)*	79 (2)	74 (2)
Control							
Systolic	133 (4)	123 (4)*	137 (5)	143 (4)*	138 (4)	133 (3)	128 (3)
Diastolic	76 (2)	75 (3)	89 (3)*	87 (3)*	85 (3)*	79 (2)	74 (3)

* $p < 0.05$ compared to pre-induction values.

Table 5. Mean (SEM) maximum increases in systolic and diastolic pressures (mmHg) from pre-intubation levels.

	Fibreoptic group	Control group
Systolic	30 (4)*	21 (3)
Diastolic	20 (3)*	14 (2)

* $p < 0.05$ between groups.

in heart rate occurred during the second minute after intubation in the fibreoptic group, and during the first minute after intubation in the control group. The heart rate during the second minute after intubation was significantly greater in the fibreoptic group than in the control group.

The mean systolic arterial pressure decreased significantly after induction in both groups (Table 4). Tracheal intubation caused an increase in systolic pressure, which peaked 2 minutes after intubation, when values in both groups were significantly greater than those before induction. Systolic pressure remained elevated in the fibreoptic group during the third minute after intubation, but returned to pre-induction levels in the control group. Tracheal intubation was also associated with a significant increase in diastolic pressure in both groups during the first, second and third minutes after intubation compared with pre-induction values. Diastolic pressure reached a maximum one minute after intubation in the control group and 2 minutes after intubation in the fibreoptic group, but the differences between the groups were not statistically significant.

The mean maximum increase in systolic pressure from pre-intubation level was 30 mmHg in the fibreoptic group; this was significantly greater than that in the control group (21 mmHg; Table 5). Similarly, the mean maximum increase in diastolic pressure from pre-intubation level was 20 mmHg in the fibreoptic group compared to 14 mmHg in the control group.

Discussion

Fibreoptic-assisted intubation can be valuable in conditions which make direct laryngoscopy with a Macintosh laryngoscope impossible, for example trismus or anterior larynx. Consequently, an increasing number of anaesthetists are acquiring skill in the use of fibreoptic techniques, so that these difficult cases can be managed successfully. The purpose of this study was to assess the cardiovascular changes during this procedure.

It might have been expected that use of the fibreoptic laryngoscope would attenuate the normal pressor response to intubation, because the Macintosh blade applies direct mechanical pressure to the base of tongue, in order to lift the tongue and epiglottis forwards. Animal studies[21] showed that the anterior pharynx is particularly sensitive to noxious stimuli; stimulation of this region produced a greater sympathetic reaction than any other part of the airway. It is not necessary with the flexible laryngoscope to convert the angular path from incisor teeth to larynx into a straight line, and thus direct pressure on the anterior pharynx is not required.

However, the results of this study show that this method of fibreoptic intubation results in a more severe pressor response than the standard laryngoscope. One explanation for this may be that the traction on the tongue which is necessary to clear the airway is itself as potent a stimulus as the Macintosh blade. Alternatively, the response may be related to the increased time taken to achieve intubation when the fibreoptic laryngoscope was used; Stoelting[22] demonstrated that increased duration of laryngoscopy with a Macintosh blade caused a progressive increase in mean arterial pressure. Fibreoptic intubation nearly always takes longer than orthodox intubation, because the field of view is restricted. Ovassapian[23] suggested in 1983, that cardiovascular responses were reduced when awake fibreoptic nasal intubation was performed under sedation and topical anaesthesia. He found that, on average, mean arterial pressure increased by 10 mmHg and heart rate by 14 beats/minute; these are modest changes compared with the findings of the present study. However, Ovassapian's trial was not controlled, and the possibility that the responses to the rigid laryngoscope would also have been reduced in these circumstances cannot be excluded. There is evidence that the application of topical anaesthesia to the airway before intubation attenuates the pressor response[22,24–26] and this, rather than any specific effect of the fibreoptic laryngoscope, may account for the more favourable results.

Anaesthetists who use this method of fibreoptic intubation should be aware that it appears to generate a more severe pressor response than orthodox intubation. Therefore, it should not be used in patients with hypertension, ischaemic heart disease or cerebrovascular atherosclerosis, unless appropriate measures are taken to suppress the cardiovascular responses to intubation.

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References

1. Murphy P. A fibre-optic endoscope used for nasal intubation. *Anaesthesia* 1967; **22:** 489–91.
2. Taylor PA, Towey RM. The broncho-fiberscope as an aid to endotracheal intubation. *British Journal of Anaesthesia* 1972; **44:** 611–2.
3. Raj PP, Forestner J, Watson TD, Morris RE, Jenkins MT. Technics for fiberoptic laryngoscopy in anesthesia. *Anesthesia and Analgesia* 1974; **53:** 708–14.
4. Styles CM. A flexible fiberoptic bronchoscope for endotracheal intubation of infants. *Anesthesia and Analgesia* 1974; **53:** 1017–9.
5. Anderton JM. Difficulty in intubation. *British Journal of Anaesthesia* 1978; **50:** 1267.
6. Messeter KH, Pettersson KI. Endotracheal intubation with the fibre-optic bronchoscope. *Anaesthesia* 1980; **35:** 294–8.
7. Lloyd EL. Fibreoptic laryngoscopy for difficult intubation. *Anaesthesia* 1980; **35:** 719.
8. Sia RL, Edens ET. How to avoid problems when using the fibre-optic bronchoscope for difficult intubations. *Anaesthesia* 1981; **36:** 74–5.
9. Witton TH. An introduction to the fiberoptic larygoscope. *Canadian Anaesthetists' Society Journal* 1981; **28:** 475–8.
10. Ovassapian A, Dykes MHM, Golmon ME. A training programme for fibreoptic nasotracheal intubation. Use of model and live patients. *Anaesthesia* 1983; **38:** 795–8.
11. Rogers SN, Benumof JL. New and easy techniques for fiber-optic endoscopy-aided tracheal intubation. *Anesthesiology* 1983; **59:** 569–72.
12. Latto IP, Rosen M. *Difficulties in tracheal intubation.* London: Bailliere Tindall, 1985.
13. King BD, Harris LC, Greifenstein FE, Elder JD, Dripps RD. Reflex circulatory responses to direct laryngoscopy and

tracheal intubation performed during general anesthesia. *Anesthesiology* 1951; **12:** 556–66.

14. Wycoff CC. Endotracheal intubation: effects on blood pressure and pulse rate. *Anesthesiology* 1960; **21:** 153–8.
15. Prys-Roberts C, Greene LT, Meloche R, Foex P. Studies of anaesthesia in relation to hypertension 11: Haemodynamic consequences of induction and endotracheal intubation. *British Journal of Anaesthesia* 1971; **43:** 531–47.
16. Russell WJ, Morris RG, Frewin DB, Drew SE. Changes in plasma catecholamine concentrations during endotracheal intubation. *British Journal of Anaesthesia* 1981; **53:** 837–9.
17. Roy WL, Edelist G, Gilbert B. Myocardial ischemia during non-cardiac surgical procedures in patients with coronary-artery disease. *Anesthesiology* 1979; **51:** 393–7.
18. Fox EJ, Sklar GS, Hill CH, Villanueva R, King BD. Complications related to the pressor response to endotracheal intubation. *Anesthesiology* 1977; **47:** 524–5.
19. Katz RL, Bigger JT Jr. Cardiac arrhythmias during anesthesia and operation. *Anesthesiology* 1970; **33:** 193–213.
20. Burney RG, Winn R. Increased cerebrospinal fluid pressure during laryngoscopy and intubation for induction of anesthesia. *Anesthesia and Analgesia* 1975; **54:** 687–90.
21. Tomori Z, Widdicombe JG. Muscular, bronchomotor and cardiovascular reflexes elicited by mechanical stimulation of the respiratory tract. *Journal of Physiology* 1969; **200:** 25–49.
22. Stoelting RK. Circulatory changes during direct laryngoscopy and tracheal intubation: influence of duration of laryngoscopy with or without prior lidocaine. *Anesthesiology* 1977; **47:** 381–3.
23. Ovassapian A, Yelich SJ, Dykes MHM, Brunner EE. Blood pressure and heart rate changes during awake fiberoptic nasotracheal intubation. *Anesthesia and Analgesia* 1983; **62:** 951–4.
24. Ward RJ, Allen GD, Deveny LJ, Green HD. Halothane and the cardiovascular response to endotracheal intubation. *Anesthesia and Analgesia* 1965; **44:** 248–52.
25. Kautto UM, Heinonen J. Attenuation of circulatory response to laryngoscopy and tracheal intubation: a comparison of two methods of topical anaesthesia. *Acta Anaesthesiologica Scandinavia* 1982; **26:** 599–602.
26. Abou-Madi M, Keszler H, Yacoub O. A method for prevention of cardiovascular reactions to laryngoscopy and intubation. *Canadian Anaesthetists' Society Journal* 1975; **22:** 316–29.

Anaesthesia, 1988, Volume 43, pages 633–634

Low volume intercostal injection. A comparative study in patients and cadavers

A. MOWBRAY AND K. K. S. WONG

Summary

This study compared the spread of 3 ml of a solution of bupivacaine–methylene blue in the intercostal space of patients and cadavers. There were 51 successful injections in each group which demonstrated in 86% of patient injections and 84% of cadaver injections that spread was confined to one intercostal space. Spread was more extensive in cadavers, probably as a result of autolysis. It would therefore still appear necessary, when low volumes of local anaesthetic are used, to block each intercostal nerve individually.

Key words

Anaesthetic techniques, regional; intercostal block.

Intercostal nerve blockade has been popular for many years, used extensively in the operating theatre, intensive care unit and pain clinic. The traditional technique involves individual injection of local anaesthetic under each rib.[1] However, a report of extremely wide spread from a single injection,[2] raises the possibility that not every intercostal space need be injected to achieve successful blockade, therefore reducing the risk of pneumothorax. Several studies have investigated spread; most have been performed on cadavers[2–4] using India ink or liquid latex, or in patients with radio-opaque contrast.[5] This study, divided into two parts, compared the spread of a typical anaesthetic solution in patients and cadavers.

Methods

Patients

Forty-one patients scheduled for elective thoracotomy participated, since intercostal blockade was an integral part of our technique. A standard anaesthetic sequence was used in every case, and included a double lumen bronchial tube. Electrocardiograph and intra-arterial pressure were monitored in every patient after induction. Patients were placed in the lateral position for surgery, and intercostal injection was then performed with a solution of 0.5% bupivacaine plain 20 ml and 1% methylene blue 1 ml as described previously.[6]

The injection technique was as follows: a 23-gauge hypodermic needle on a 10-ml syringe was inserted perpendicular to the skin surface down on to the seventh rib posteriorly at its angle. The needle was then walked inferiorly off the rib and advanced approximately 4 mm into the intercostal space. Three millilitres of the solution was injected after negative aspiration for blood or air. In the first 18 patients only one injection was performed but in the others two or three injections were given at approximately fifth, seventh and tenth interspaces.

Routine thoracotomy followed until the pleura was opened. The lung was collapsed at this stage and gently retracted, with disturbance to the parietal pleura kept to a minimum. The spread could be easily seen, because of the indicator in the solution, and was quantified in terms of the number of intercostal spaces discoloured and the maximum spread of the blue patch along the space. It was noted whether the lung failed to collapse or intrapleural dye was detected, as was the time from injection to visualisation. Dye was considered to occupy an interspace if it reached the superior part that contained the neurovascular bundle. Definitive surgery proceeded after quantifying the spread of dye.

Cadavers

Eleven cadavers about to undergo routine necropsy were investigated; all had died within the previous 48 hours. The first four cadavers had intercostal injections performed in the prone position before evisceration, but it was found that the bodies were easier to handle and blood pooling in the thorax was less troublesome if evisceration was carried out first and then the blocks performed.

The solution, injection technique and method of measurement were identical to that in the patient group, except that injections were performed bilaterally which resulted in

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Table 1. Patient and cadaver characteristics.

	Patients	Cadavers
Male	31	6
Female	10	5
Mean age	40	68
Mean weight, kg	53	57
Mean visualisation time, minutes (range)	13 (10–18)	16 (5–30)
Length of spread, cm (SD)	5.2 (1.4)	8.6 (1.8)

Table 2. Reasons for failure.

Patients	Tumour involving chest wall	2
	Empyema	3
	Intrapleural injection	4
	Subcutaneous/intramuscular injection	2
Cadavers	Pleural adhesions	1
	Intrapleural injection	2
	Subcutaneous/intramuscular injection	2

Table 3. Characteristics of spread.

Number of interspaces involved	Number of patients	Number of cadavers
1	44	43
2	7	6
3	0	2

between two and six injections in each cadaver. Breach of the parietal pleura in any way during dissection led to exclusion of that hemithorax from the study. Injection to visualisation time was also noted.

Results

The characteristics of the patient and cadaver groups are detailed in Table 1. There were 51 successful intercostal injections and 11 failures in the patient group; in the cadaver group 51 successful injections and five failures. The reasons for failure are given in Table 2.

The characteristics of the spread are listed in Table 3. The maximum length of the patch was 5.2 cm (SD 1.4) in patients and 8.6 cm (SD 1.8) in cadavers. This difference was statistically significant ($p < 0.001$). Spread was restricted to one interspace in 86% of patient injections and 84% of cadaver injections. In only two cadaver injections were three interspaces discoloured by methylene blue.

Discussion

Previous studies on the spread of solutions in the intercostal space of patients and cadavers have yielded conflicting results. There has been a paucity of reports which compare spread of clinically relevant material (e.g. bupivacaine) despite a growing number of investigations in cadavers[2–4] and patients/volunteers.[5–7] It is known that the intercostal space is extremely vascular with rapid absorption characteristics[5] and this may be an important point in relating data collected in cadavers to patients. Methods of investigation may also produce difficulties in interpretation; for instance in studies using radio-opaque contrast media, how do the investigators know that injected contrast lies in the intercostal space as opposed to the pleural cavity? One study[7] was presumed to illustrate intercostal injection because contrast was uninfluenced by gravity but this has also been shown with intrapleural injections.[8]

This study illustrates the differences between patients and cadavers, when a local anaesthetic/indicator solution is used. The main distinction is in the significant difference in the length of spread which is 5.2 cm (SD 1.4) and 8.6 cm (SD 1.8) in patients and cadavers respectively. This marked increase in spread in cadavers is probably because of autolysis and therefore the extent of spread may be related to the time since death and ambient temperature. A second and statistically insignificant difference is that in two injections in cadavers there was spread to involve three interspaces, but this did not occur in the patient group.

Spread was restricted to one interspace in 86% of patient injections and 84% of cadaver injections; this suggests that when intercostal blockade is performed it is unreliable to assume that 3 ml of local anaesthetic solution will produce analgesia of more than one dermatome. The incidence of intrapleural injection was 6.5% (four out of 62) in patients and 3.5% (two out of 56) in cadavers. However, since material injected into the intercostal space is relatively uninfluenced by gravity[8] local anaesthetic deposited here may still diffuse through the parietal pleura to produce clinical intercostal blockade.

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References

1. Moore DC, Bridenbaugh LD. Intercostal nerve block in 4333 patients: indications, technique, and complications. *Anesthesia and Analgesia* 1962; **41**: 1–11.
2. Nunn JF, Slavin G. Posterior intercostal nerve block for relief of pain after cholecystectomy. Anatomical basis and efficacy. *British Journal of Anaesthesia* 1980; **52**: 253–60.
3. Murphy DF. Continuous intercostal nerve blockade. An anatomical study to elucidate its mode of action. *British Journal of Anaesthesia* 1984; **56**: 627–9.
4. Moore DC. Intercostal nerve block: spread of india ink injected to the rib's costal groove. *British Journal of Anaesthesia* 1981; **53**: 325–9.
5. Moore DC, Bush WH, Scurlock JE. Intercostal nerve block: a roentgenographic anatomic study of technique and absorption in humans. *Anesthesia and Analgesia* 1980; **59**: 815–25.
6. Mowbray A, Wong KKS, Murray JM. Intercostal catheterisation. An alternative approach to the paravertebral space. *Anaesthesia* 1987; **42**: 958–61.
7. Crossley AWA, Hosie HE. Radiographic study of intercostal nerve blockade in healthy volunteers. *British Journal of Anaesthesia* 1987; **59**: 149–54.
8. Miserocchi G, Negrini D, Para AF, Pistolesi M, Miniati M, Bellina R, Giuntina C. Kinetics of the intrapleural distribution of a radioactive bolus. *Respiratory Physiology* 1986; **65**: 13–27.

Anaesthesia, 1988, Volume 43, pages 635–637

Anatomical re-evaluation of lumbar dura mater with regard to postspinal headache

Effect of dural puncture

M. DITTMANN, H.-G. SCHÄFER, J. ULRICH AND W. BOND-TAYLOR

Summary

The effects of puncture of fresh cadaver dura with 20-, 22-, 26- and 29-gauge needles were observed. A 'tin-lid' phenomenon, manifested with all needle sizes, was capable of sealing the resultant hole. The larger the needle, the larger the hole, while rotation of the needle bevel 90° to the fibres altered the shape of the hole. Holes made in thicker parts of the dura tended to retract more rapidly than those in thinner areas.

Key words

Anaesthetic techniques, regional; spinal.
Complications; headache.

Spinal anaesthesia has been in use for 100 years but the debate that surrounds the cause of postspinal headache continues. The most plausible explanation is leakage. The spinal needle traverses the dura and produces a hole through which cerebrospinal fluid (CSF) leaks. The loss of spinal fluid in the upright position results in traction on the brain, which induces the typical frontal headache and possibly nausea, vomiting and dizziness. The headache disappears on adoption of the supine position; this phenomenon is reproducible.

It was decided to examine the gross structure of the dura mater in the lumbar region and to observe the effect of dural puncture with needles of different sizes.

Methods

Fresh preparations of dura were obtained from the lumbar region of five cadavers, and the gross anatomy examined. The dura was punctured with Quincke needles of sizes 20, 22, 26 and 29 gauges with the bevels as parallel as possible to the dural fibres and the resultant holes examined. The needle bevels were then rotated through 90° and re-introduced through the dura. The effects of penetration of the dura in areas of different thickness were also observed.

Results

Figure 1 is typical of the dura obtained: the fibres were not uniformly parallel and the thickness varied from between 0.5 to almost 2.0 mm. The effect of puncture of the dura with different size needles, the bevels as parallel as possible to the fibres, is shown in the top left of Fig. 2. A 'tin-lid' phenomenon was evident with each needle size: the perforation resembled the top of a tin that had been almost completely opened, but with the lid hinged at one point. The top four punctures in the bottom right of Fig. 2 show the holes left when the needle bevels had been turned through 90°; they were somewhat rounder and the 'tin-lid' phenomenon was seen again.

The hole tended to be ellipsoidal when a needle was inserted through a thick part of the dura and after a short time tended to shrink (Figs 3a and b). On the other hand, when the same size needle penetrated a thinner part of the dura the resultant hole was larger and shrank much more slowly. Finally, it was observed that even with 20-gauge needles the 'tin-lid' phenomenon could effectively close the hole in the dura. This may explain why in some patients, especially the elderly who have a physiological lower CSF pressure, postspinal headache does not develop despite the use of large gauge needles.

Discussion

We have found that the texture of dura mater and especially the arrangement of the elastic fibres is not uniform as stated in earlier reports.[1-3] The variation in puncture-hole size depends on the thickness of the dura at the penetration site; the retraction force is greater where the dura is thicker.

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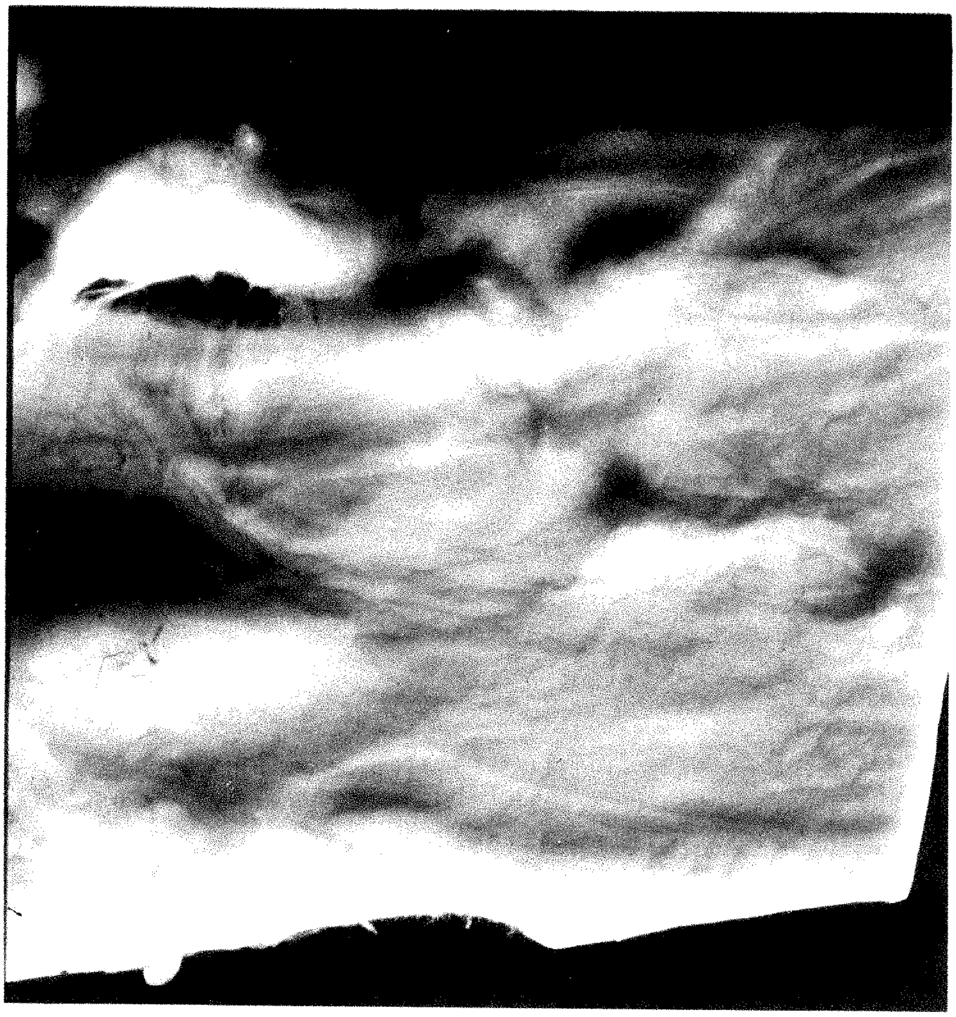

Fig. 1. Sample of lumbar dura mater that shows variation in thickness and that the fibres are not all parallel.

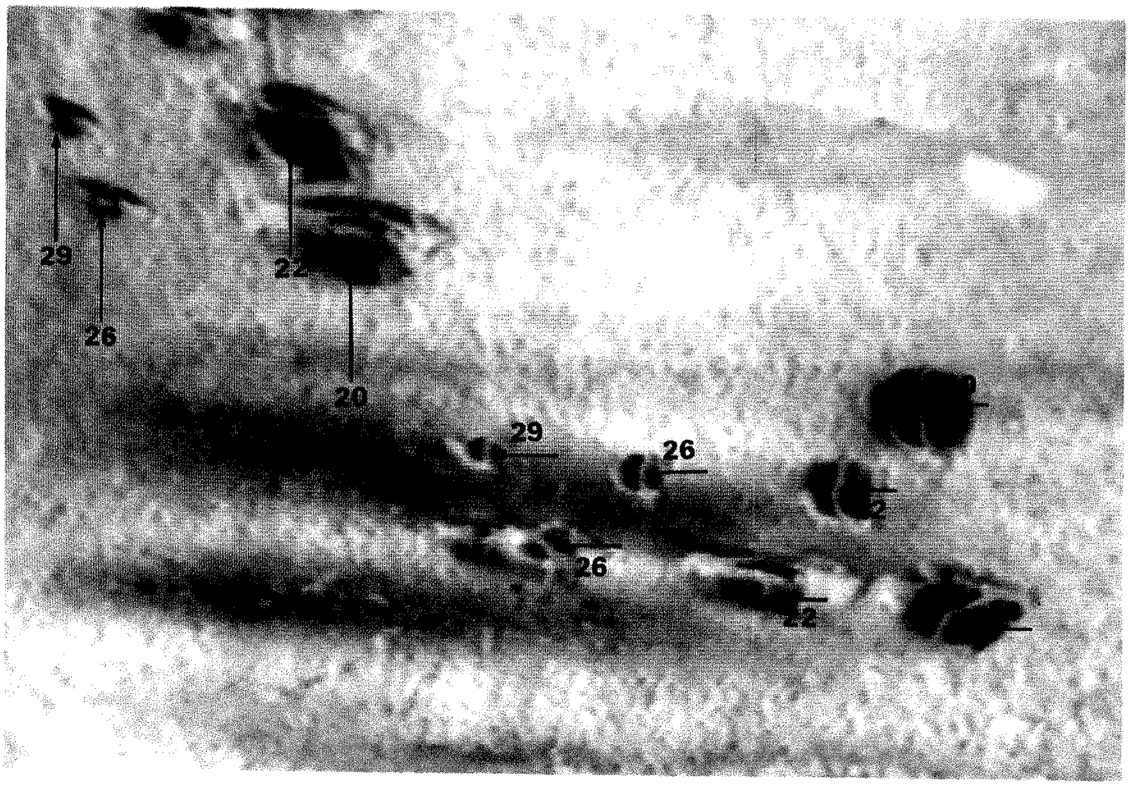

Fig. 2. Effects of puncture of the dura with needles of different sizes. The punctures in the top left are made with the needle bevels as parallel as possible to the dural fibres and those in the upper row in the bottom right with the bevels rotated through 90°. The 'tin-lid' effect can be seen clearly and is arrowed. The figures refer to the needle sizes.

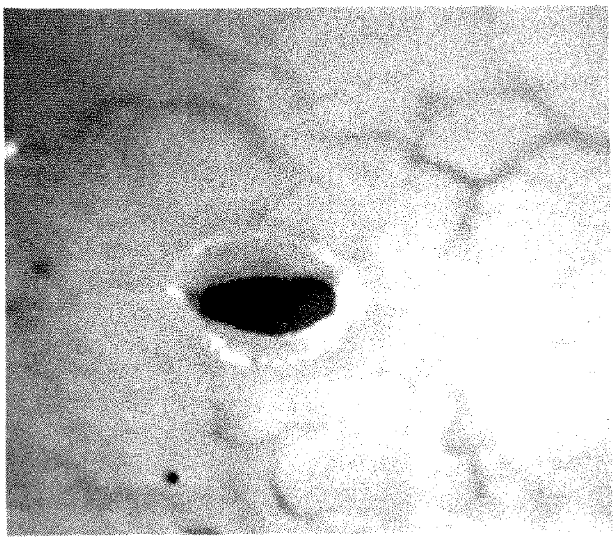

Fig. 3a. Dural puncture made in thick tissue with a 22-gauge needle.

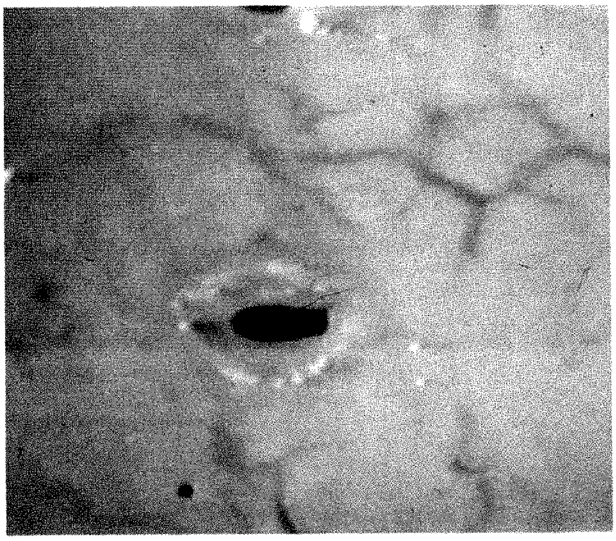

Fig. 3b. The same puncture hole 15 seconds later.

The most important factor that determines the sizes of the hole is the size of the needle. The size and shape of the hole depends to a much lesser extent on the direction of the needle bevel; the shape is either round or ellipsoidal.

This study has shown that spinal needle puncture produces a 'tin-lid' phenomenon in the dura, which in turn is capable of closing holes produced by the largest spinal needles. Puncture wounds made where the dura is thickest tend to retract more readily than in thin areas, while alteration of the direction of the bevel tends to change only the shape of the hole. These findings may explain some of the discrepancies between the reports that investigated the incidence of postspinal headache.

References

1. GREENE HM. Lumbar puncture and the prevention of postpuncture headache. *Journal of the American Medical Association* 1926; **86:** 391–2.
2. FRANKSSON C, GORDH T. Headache after spinal anaesthesia and a technique for lessening its frequency. *Acta Chirurgica Scandinavica* 1946; **94:** 443–54.
3. MIHIC DN. Postspinal headache and relationship of needle bevel to longitudinal dural fibres. *Regional Anaesthesia* 1985; **10:** 76–81.

Anaesthesia, 1988, Volume 43, pages 638–640

The effects of thiopentone and propofol on upper airway integrity

K. McKEATING, I. M. BALI AND J. W. DUNDEE

Summary

One hundred and fifty-eight unpremedicated patients scheduled for elective surgery were allocated randomly to receive an unsupplemented induction dose of thiopentone or propofol. Visualisation of the vocal cords by standard laryngoscopy was possible more often after propofol ($p < 0.01$). Pharyngeal and laryngeal reactivity was similarily depressed more frequently.

Key words

Anaesthetics, intravenous; thiopentone, propofol.
Larynx; laryngoscopy.

Tracheal intubation may be facilitated by the use of a neuromuscular blocking drug. However, in the absence of such an agent certain other anaesthetic drugs are known to obtund the laryngeal reflex.[1–5] Previous workers have shown that the choice of intravenous induction agent may influence intubating conditions and suggest that this is due to depression of the laryngeal reflex.[5]

Widely abducted immobile vocal cords were frequently observed at laryngoscopy following the unsupplemented administration of propofol. Other workers suggest that operation conditions for microlaryngeal surgery are improved when anaesthesia is induced and maintained with propofol.[6] This study was designed to assess and compare the depressant effects of thiopentone and propofol on upper airway integrity.

Methods

One hundred and fifty-eight healthy consenting patients scheduled for elective surgery were admitted to the study, with University Medical Ethics Committee approval. Anaesthesia was induced with propofol 2.5 mg/kg or thiopentone 4 or 5 mg/kg intravenously by random allocation. Airway assessment, at 45 seconds (thiopentone) and at 45, 90 and 120 seconds (propofol), was carried out by an observer unaware of the drug given and of the assessment time.

ECG and systemic arterial blood pressure were monitored continuously before, during and after anaesthesia. The induction agent was injected into a large forearm vein over 20–30 seconds. Patients breathed oxygen 8 litres/minute by facemask and ventilation was assisted manually when necessary for the duration of the assessment. Thereafter anaesthesia was maintained with intravenous or inhalational agents as required.

The time to loss of eyelash reflex and occurrence of apnoea were recorded immediately after intravenous injection. Jaw tone and the pharyngeal reflex were assessed by gentle introduction of the laryngoscope blade into the patient's mouth and pharynx. If laryngoscopy was possible it was performed in the standard way and vocal cord position and mobility were noted. The assessment continued only when abducted immobile vocal cords were viewed. The final assessment steps involved the gentle application of a tracheal tube stylet to the posterior commissure of the vocal cords. If no reaction occurred the stylet was further introduced to make contact with tracheal mucosa and any response noted. The reflex was described as active when a local response to stimulation was observed. Results were analysed using the Chi-squared test with Yates' correction for small numbers or Fisher's Exact Probability Test as appropriate.

Results

The five groups were comparable in respect of age, sex, weight and smoking habit (Table 1). Anaesthesia was successfully induced in all patients. Forty-five seconds after thiopentone, 14 (56%) patients given 4 mg/kg and eight (27%) given 5 mg/kg had active pharyngeal reflexes, compared with none of the 38 given propofol ($p < 0.001$, Table 2).

Laryngoscopy was possible at 45 seconds in all patients given propofol compared with 9 (36%) given 4 mg/kg and

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Table 1. Patient characteristics.

	Thiopentone		Propofol		
Dose (mg/kg)	4	5	2.5		
Assessment time, seconds	45	45	45	90	120
Number	25	30	38	35	30
Women	18	24	26	23	22
Smokers	11	11	13	13	13
Age, years (SD)	34 (11)	35 (11)	35 (11)	32 (11)	34 (11)
Weight, kg (SD)	68 (14)	66 (10)	67 (12)	67 (14)	68 (13)

Table 2. Time (seconds) to loss of eyelash reflex. Frequency of apnoea, of satisfactory jaw tone and of diminished pharyngeal reflexes.

	Thiopentone		Propofol		
Dose (mg/kg)	4	5	2.5		
Assessment time, seconds	45	45	45	90	120
Eyelash reflexes lost, seconds	12	11		9*	
Apnoea, percent	56	56		75*	
Satisfactory jaw tone, percent	68	84	100	98	97
Diminished pharyngeal reflex, percent	44	73	100	96	91

* pooled figures for the three propofol groups

20 (66%) given 5 mg/kg of thiopentone ($p < 0.001$ and < 0.01 respectively). Similarly, more patients who received propofol had immobile abducted vocal cords than those who received either dose of thiopentone ($p < 0.001$ and 0.01, Table 3). The four patients who reached the final assessment stage after thiopentone reacted to vocal cord contact. The vocal cords after propofol were unreactive in 17 of the 24 patients assessed at 45 seconds. Of the 17 patients with unresponsive vocal cords 11 offered no response to tracheal contact when assessed at 45 seconds (Table 4).

Apnoea occurred in 56% of patients who received either dose of thiopentone compared to 75% of patients given propofol, a significant difference ($p < 0.01$, Table 2). Jaw tone was recorded as satisfactory when normal or diminished. It was satisfactory more often after propofol at 45 seconds than after thiopentone 4 or 5 mg/kg (Table 2, $p < 0.001$ and < 0.05). The eyelash reflex was lost more rapidly on average after propofol than after thiopentone at either dosage, the difference was not significant.

Table 3. Frequency (percent) of successful laryngoscopy, abducted and immobile vocal cords.

	Thiopentone		Propofol		
Dose (mg/kg)	4	5	2.5		
Assessment time, seconds	45	45	45	90	120
Successful laryngoscopy, percent	36	66	100	97	90
Abducted vocal cords, percent	22	10	63	39	30
Immobile vocal cords, percent	22	10	82	48	74

Table 4. Number of patients with unreactive upper airway.

	Thiopentone		Propofol		
Dose (mg/kg)	4	5	2.5		
Assessment time, seconds	45	45	45	90	120
Total numbers	25	30	38	35	30
Number assessed	2	2	24	13	8
Vocal cords unreactive	0	0	17	8	5
Trachea unreactive	Not tested		11	7	3

Response to vocal cord or tracheal contact was transient in those patients who displayed reflex activity and did not require intervention at any time.

Discussion

This study investigated the depressant effects of induction doses of thiopentone and propofol on airway integrity and reactivity. Thiopentone was investigated at two dose levels due to controversy as to the ratio of equal potency of thiopentone to propofol.[7,8] There was no significant difference in observations at either dose of thiopentone. Easy placement of an oropharyngeal airway was observed by Mackenzie and Grant;[9] this is indirect evidence of decreased jaw tone and diminished pharyngeal reflexes. De Grood *et al.*[10] found greater relaxation of the vocal cords after induction of anaesthesia with propofol. Satisfactory jaw tone and depressed pharyngeal reflexes in the present study were observed more often after propofol than after thiopentone. It was possible in almost all patients induced with propofol to perform laryngoscopy safely and smoothly at 45, 90 and 120 seconds. The ease of laryngoscopy and absence of tracheal response in almost a third of patients assessed after propofol-induced anaesthesia may provide better conditions for intubation of the trachea.

A number of methods have been employed to assess the reactivity of the airways after the administration of anaesthetic drugs.[11–14] Mechanical methods may not be applicable before induction of anaesthesia in contrast to chemical techniques of assessment, and may suffer a lack of standardisation of stimulus between patients. However, the method of assessment used here, standard laryngoscopy and direct stimulation of the vocal cords and trachea with a tracheal tube stylet, has an advantage in that it is a standard technique employed routinely in clinical practice. This lack of pharyngeal and laryngeal reactivity may be of great benefit when these regions are being instrumented but it must give rise to concern especially where the risk of tracheal aspiration of stomach contents, or other foreign matter, is increased. The absence of tracheal reaction in almost a third of patients assessed by direct contact of the tracheal mucosa at 45 seconds may cause concern. However effective application of Sellick's manoeuvre could overcome this danger.[15]

References

1. Groves ND, Rees JL, Rosen M. Effects of benzodiazepines on laryngeal reflexes. Comparison of lormetazepam and diazemuls. *Anaesthesia* 1987; **42:** 808–14.
2. Carson IW, Moore J, Balmer JP, Dundee JW, McNabb TG. Laryngeal competence with ketamine and other drugs. *Anesthesiology* 1973; **38:** 128–33.
3. Horita A, Dille JM. Observations on the action of thiopental (pentothal) on the laryngeal reflex. *Anesthesiology* 1955; **16:** 848–53.
4. Yukioka H, Yoshimoto N, Nishimura K, Fujimori M. Intravenous lidocaine as a supressant of coughing during tracheal intubation. *Anesthesia and Analgesia* 1985; **64:** 1189–92.
5. Bali IM, Dundee JW. Effect of i.v. induction regimens on

endotracheal intubation with alcuronium and atracurium. *British Journal of Anaesthesia* 1985; **57:** 830P–1P.

6. De Grood PMRM, Mitsukuri S, Van Egmond J, Rutten JMC, Crul JF. Comparison of etomidate and propofol for anaesthesia in microlaryngeal surgery. *Anaesthesia* 1987; **42:** 366–72.
7. Grounds RM, Moore M, Morgan M. The relative potencies of thiopentone and propofol. *European Journal of Anaesthesiology* 1986; **3:** 11–7.
8. McCollum JSC, Dundee JW. Comparison of induction characteristics of four intravenous anaesthetic agents. *Anaesthesia* 1986; **41:** 995–1000.
9. Mackenzie N, Grant IS. Comparison of the new emulsion formulation of propofol with methohexitone and thiopentone for induction of anaesthesia in day cases. *British Journal of Anaesthesia* 1985; **57:** 725–31.
10. De Grood PMRM, Van Egmond J, Wetering M Van De, Van Beem HB, Booij LHDJ, Crul JF. Lack of effects of emulsified propofol (Diprivan) on vecuronium pharmacodynamics—preliminary results in man. *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 28–30.
11. Hinkle JE, Tantum KR. A technique for measuring the reactivity of the glottis. *Anesthesiology* 1971; **35:** 634–7.
12. Rosen M, Harrison GA. Depression of the laryngeal reflexes by general and topical anaesthesia. An assessment of the relative parts played by halothane and nitrous oxide anaesthesia, and by lignocaine when applied by different methods. *Anaesthesia* 1963; **18:** 343–9.
13. Taylor PA, Towey RM. Depression of laryngeal reflexes during ketamine anaesthesia. *British Medical Journal* 1971; **2:** 688–9
14. Bickerman HA, Cohen BM, German E. The cough response of normal human subjects stimulated experimentally by citric acid aerosol: alterations produced by antitussive agents. *American Journal of Medical Science* 1956; **232:** 57–65.
15. Sellick BA. Cricoid pressure to control regurgitation of stomach contents during induction of anaesthesia: preliminary communication. *Lancet* 1961; **2:** 404–6.

Anaesthesia, 1988, Volume 43, pages 641–643

Diclofenac sodium for post-tonsillectomy pain in children

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Summary

Diclofenac sodium was assessed as an analgesic for postoperative pain following paediatric tonsillectomy in a randomised double blind trial. In a comparison made with both a pethidine and a control group diclofenac was shown to be an effective analgesic. No significant difference in analgesic efficacy was demonstrated between the two drugs, although patients who received diclofenac tended to be less drowsy postoperatively than those who received pethidine. There were no significant differences between the two drugs in respect of time to awaken from anaesthesia or incidence of postoperative vomiting.

Key words

Analgesics, anti-inflammatory; diclofenac sodium.
Tonsillectomy; paediatric.

Diclofenac sodium is a nonsteroidal anti-inflammatory analgesic drug which is available as an intramuscular preparation. It is advocated for use in rheumatoid arthritis, degenerative joint disease and allied conditions and for the treatment of pain which results from minor surgery.[1] Its anti-inflammatory action may benefit patients after tonsillectomy, since its absence of sedative properties would be an advantage after surgery which involves the upper airway.

The aim of the study was to determine whether diclofenac is an effective analgesic for children after tonsillectomy. A comparison was made with pethidine, which is used commonly for paediatric analgesia, in relation to efficacy, speed of recovery, sedation and nausea or vomiting.

Methods

Seventy-five children of ASA grade 1 or 2 and aged 5–12 years, who were admitted for tonsillectomy with or without adenoidectomy or myringotomy, were studied. Approval was given by the local ethics committee and informed parental consent was obtained. Children with a history of allergy or intolerance to anti-inflammatory drugs were excluded.

A standard anaesthetic technique was used. Premedication was temazepam 0.5 mg/kg and atropine 0.03 mg/kg given orally 2 hours pre-operatively. Anaesthesia was induced with thiopentone 5 mg/kg followed by suxamethonium 1 mg/kg to facilitate intubation. A mixture of halothane in nitrous oxide and oxygen was administered via a T-piece or Bain system for maintenance of anaesthesia; all patients breathed spontaneously. Patients were allocated randomly to receive either diclofenac 1 mg/kg, pethidine 1 mg/kg or no analgesia (control group) after induction of anaesthesia. The analgesic drug was given by deep intramuscular injection into the lateral compartment of the thigh. Pethidine 1 mg/kg was given intramuscularly in the recovery ward if thought necessary by the recovery nurse, who was not aware which drug, if any, had been given intra-operatively. Oral paracetamol elixir was used as the first analgesic in the ward.

Times of premedication, intramuscular injection and end of anaesthesia were noted. The time to awaken (when the patient first responded to verbal command) and the time to administration of the first postoperative analgesia were also recorded. Pain was assessed by the patients' use of a visual analogue toy,[2] (Fig. 1), when they awoke and at 30 minutes, one hour, 4 hours and 24 hours postoperatively. All the children were shown the visual analogue toy during the pre-operative visit, and its use was explained to them. The rocket could move 10 inches (the length of the piece of K-nail to which it was attached) and a scale was marked on the reverse side from 0 (bottom) to 10 (top) in tenths of an inch. No pain was represented at the bottom and the worst pain imaginable at the top, but the children did not see the scale when they moved the rocket. The marker on the rocket correlated to the black line at the bottom of the 'A' of USA.

One of two recovery nurses also assessed the patients' pain with a standard visual analogue scale when they

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Table 1. Characteristics of 75 children who underwent tonsillectomy. Mean (SEM), or frequency.

	Control (n = 25)	Diclofenac (n = 25)	Pethidine (n = 25)
Age (years)	7.3 (0.4)	6.6 (0.4)	7.1 (0.4)
Weight (kg)	25.2 (1.4)	23.6 (1.2)	25.8 (1.4)
Premedication time (minutes before induction)	152 (11)	146 (8)	157 (8)
Duration of operation (minutes)	27.7 (1.9)	28.6 (1.9)	25.8 (2.0)
Males:females	13:12	11:14	11:14
Types of operation			
T	5	6	4
T + A	10	7	17
T + M	1	2	1
T + A + M	9	10	3

T, Tonsillectomy; A, Adenoidectomy; M, Myringotomy.

awoke, and 30 minutes and one hour postoperatively. The presence of nausea and vomiting was noted at the same times. Drowsiness was assessed at each observation time using a four-point scale: awake; slightly drowsy; drowsy but rousable; or very drowsy/asleep. Groups were assessed for comparability by use of one-way analysis of variance or Chi-squared tests for contingency tables as appropriate. The purpose of the study was to assess the efficacy of diclofenac in relation to pethidine and no analgesic; thus, the statistical analysis was confined to comparisons between these groups. Visual analogue scores, drowsiness scores, times to awakening and times to first postoperative analgesia were analysed using the non-parametric Mann–Whitney *U* test.

Results

There were no significant differences between the groups in respect of age, weight, sex, time of premedication prior to surgery, or duration or type of operation (Table 1). The results in Table 2 show the variability of tonsillectomy pain: four of the control group required only paracetamol for analgesia whereas 12 of the pethidine group required more pethidine in recovery. The time interval before they awoke tended to be longer in the pethidine group than in the diclofenac group but this did not attain statistical significance; nor was there any statistically significant difference in awakening times between the control and diclofenac groups. The time from when they awoke to the time of requirement of analgesic was significantly greater ($p < 0.001$) in the diclofenac group than the control group, but the diclofenac and pethidine groups did not differ significantly. The diclofenac group had significantly lower

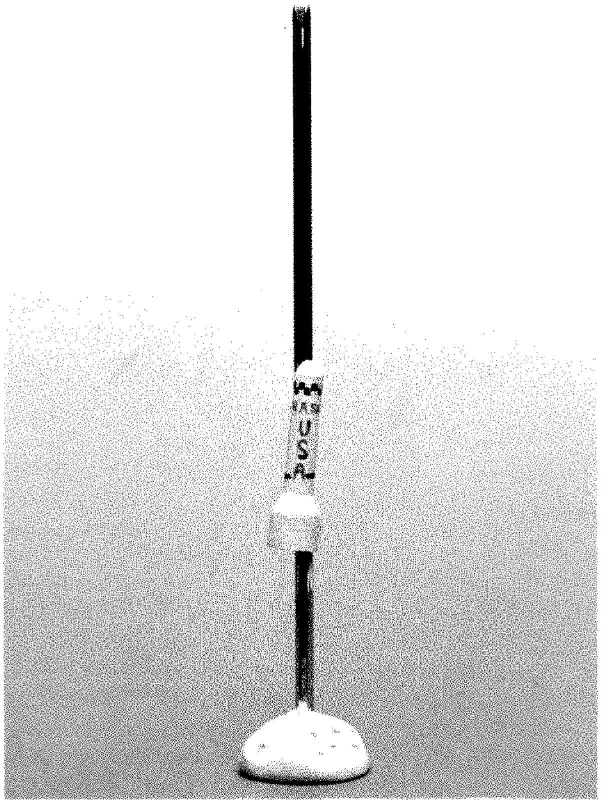

Fig. 1. Visual analogue toy for assessment of pain by children.

Table 2. Observations in the postoperative period. Median (lower, upper quartile), or frequency.

	Control (n = 25)	Diclofenac (n = 25)	Pethidine (n = 25)	Significance level (NS = $p \geqslant 0.05$) C vs D	D vs P
Time to awaken (minutes)	19 (15,26)	22 (15,33)	28 (18,36)	NS	NS
Time awake to first analgesia (minutes)	5 (1,18)	65 (9,333)	95 (20,314)	$p < 0.001$	NS
Pain score on awakening (nurse)	4.8 (1.0,6.9)	0.3 (0.0,2.5)	0.7 (0.1,2.4)	$p < 0.01$	NS
Pain score at 4 hours (patient)	3.9* (1.6,6.0)	4.0*(2.0,8.0)	7.0 †(2.7,9.6)	NS	NS
Pain score at 24 hours (patient)	2.7‡ (0.5,4.0)	2.5 (1.8,4.5)	3.0 (1.8,4.0)	NS	NS
Number requiring pethidine postoperatively	21 (84%)	13 (52%)	12 (48%)	$p < 0.05$	NS

* three patients unable to use toy; ‡ one patient unable to use toy; † eight patients unable to use toy.

Table 3. Postoperative cooperation, drowsiness and vomiting.

	Control ($n = 25$)	Diclofenac ($n = 25$)	Pethidine ($n = 25$)
Ability to use visual analogue toy			
Awake	3 (12%)	4 (16%)	4 (16%)
30 minutes	7 (28%)	10 (40%)	3 (12%)
1 hour	19 (76%)	22 (88%)	15 (60%)
4 hours	22 (88%)	22 (88%)	17 (68%)
24 hours	24 (96%)	25 (100%)	25 (100%)
Drowsiness on awakening			
Awake	2	2	0
Slight	7	5	5
Rousable	16	18	20
Asleep	–	–	–
Incidence of vomiting	19 (76%)	14 (56%)	13 (52%)
Median time to vomiting postoperatively (hours)	7.8	5.3	3.5

pain scores when they awoke as assessed by the nurse than the control group ($p < 0.01$); comparison between the pethidine and diclofenac groups showed no significant difference. The pain scores at 30 minutes and one hour postoperatively could not be compared because many of the children required pethidine in the recovery ward.

The visual analogue toy was understood by all but one of the patients. Failure to record a score at the observation time occurred on some occasions because children were too sleepy or too distressed to move the cursor. Very few patients recorded scores immediately after they awoke (Table 3). More children in the diclofenac group were able to record a score at 30 minutes compared with those in the pethidine group ($p = 0.05$) but there were still not enough pain scores at this time for statistical analysis of the results. Too many of the children had received pethidine at one hour postoperatively to make comparison of the scores useful. The children's visual analogue pain scores at 4 and 24 hours showed no significant differences between groups (Table 2). There were no significant differences between the groups in the pattern of vomiting or in assessments of drowsiness at any of the observation times, although only the drowsiness scores when they awoke were unaffected by postoperative pethidine (Table 3).

Discussion

Nonsteroidal anti-inflammatory drugs have been shown to be useful in the treatment of postoperative dental pain[3] and we have used intra-operative diclofenac successfully for postoperative pain in adults. It therefore seemed likely that diclofenac would also benefit children who underwent tonsillectomy.

The use of a control group in our study and the unproven efficacy of diclofenac in these patients dictated that suitable analgesia must be available postoperatively. Patients in all three groups could receive pethidine in the recovery ward if necessary and it was surprising that almost half the children in the pethidine group required more pethidine. This indicates that pethidine 1 mg/kg does not provide adequate analgesia for many tonsillectomy patients. There was no clinically significant respiratory depression in any of the 12 children who received two doses of pethidine.

Visual analogue scales were used in this study because they have been found to be a sensitive means to assess pain.[4,5] Few children over the age of 5 years have difficulty in understanding the concept of the visual analogue scale.[6] This was also found to be true in our study as all but one of the children were able to use the visual analogue toy, although in the immediate postoperative period many of them were too sleepy or distressed to cooperate.

Our results show that diclofenac is a useful analgesic for children after tonsillectomy since it delayed the need for postoperative analgesia and also resulted in lower pain scores when they awoke than in the control group. Comparison of the diclofenac and pethidine groups showed no significant difference in these parameters. Although there was a tendency for the pethidine group to awaken later than the other two groups this did not attain significance; it is probable that the anaesthetic agents had an overriding effect. More of the diclofenac group (40%) were able to use the visual analogue toy 30 minutes postoperatively compared with the pethidine group (12%), which indicated that children who received diclofenac were more able to cooperate at this time and were less drowsy than those given pethidine. However, this was not confirmed by the drowsiness scores, perhaps because the four-point scale was too crude a measure.

Those who vomited usually did so several hours postoperatively and there was a similar incidence of vomiting in all groups. This suggests that swallowed blood, sore throat and fluid intake had more influence than the analgesic drugs. In summary, we have found that diclofenac sodium is an effective alternative to pethidine in paediatric tonsillectomy patients and avoids the potential side effects of opiate drugs.

Acknowledgments

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References

1. Brogden RN, Heel RC, Parkes GE, Speight TM, Avery GS. Diclofenac sodium: a review of its pharmacological properties and therapeutic use in rheumatic diseases and pain of varying origin. *Drugs* 1980; **20:** 24–8.
2. White JB, Stow P. Rationale and experience with visual analogue toys. *Anaesthesia* 1985; **40:** 601–3.
3. Crossley HL, Wynn RL, Bergman SA. Nonsteroidal anti-inflammatory agents in relieving dental pain: a review. *Journal of the American Dental Association* 1983; **106:** 61–4.
4. Seymour RA. The use of pain scales in assessing the efficacy of analgesics in postoperative dental pain. *European Journal of Clinical Pharmacology* 1982; **23:** 441–4.
5. Huskisson EC. Measurement of pain. *Lancet* 1974; **2:** 1127–31.
6. Scott PJ, Ansell BM, Huskisson EC. Measurement of pain in juvenile chronic polyarthritis. *Annals of the Rheumatic Diseases* 1977; **36:** 186–7.

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Anaesthesia, 1988, Volume 43, pages 644–645

Anti-adrenal action of a subanaesthetic dose of etomidate

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Summary

The effects of subanaesthetic doses of etomidate on corticosteroid synthesis have been studied in vivo. In the group of patients who received etomidate ($n = 10$), cortisol and aldosterone responses to adrenocorticotrophic hormone were blunted, while 11 de-oxycortisol response was increased, as compared to a control group ($n = 10$). These results suggest that a single bolus of 0.04 mg/kg etomidate, which produces sedation, without loss of consciousness, is able to block adrenal 11 hydroxylase.

Key words

Anaesthetics, intravenous; etomidate.
Hormones; adrenal.

The intravenous anaesthetic etomidate is an imidazole derivate known to inhibit cortisol and aldosterone responses to ACTH.[1–9] A single dose given for induction of anaesthesia (0.3 mg/kg) blocks transiently the adrenal mitochondrial cytochrome P450-dependent enzyme 11 hydroxylase, a key enzyme in the synthesis of cortisol and aldosterone.[1,4,5,9] *In vitro* studies have shown that between 5 and 100 nmol/litre etomidate produced a marked rise in 11 de-oxycortisol, which indicated an 11 hydroxylase-block.[10,11] Subanaesthetic doses of etomidate could reach peak blood concentrations within that range.[12] This study was undertaken to assess if etomidate could inhibit adrenal steroid synthesis at doses lower than those that produce anaesthesia.

Methods

Twenty patients scheduled to undergo general anaesthesia for elective cardiac surgery were allocated randomly to either group A (pre-induction with a bolus of etomidate 0.04 mg/kg intravenously followed 3 minutes later by thiopentone 2 mg/kg and fentanyl 50 μg/kg given as an infusion over 15 minutes), or group B (induction with thiopentone 3 mg/kg and fentanyl 50 μg/kg given over 15 minutes). Informed consent was obtained from the patients, 10 in each group, whose clinical details are shown in Table 1. Both groups received pancuronium to produce neuromuscular blockade.

Anaesthesia was maintained with 50% nitrous oxide in oxygen and a further dose of fentanyl 50 μg/kg given by infusion until sternotomy. Patients receiving drugs (or with diseases) known to affect adrenal function were not studied, and all operations began between 0830 and 1100. Blood samples were obtained before injection of etomidate (group A) or thiopentone (group B); 30 minutes after the first sample was obtained, at which point a bolus of 0.25 mg of synthetic 1–24 ACTH (Nuvacthen, Ciba) was injected intravenously; and the third, 30 minutes after the second sample was obtained. All samples were taken before the initiation of cardiopulmonary bypass. Infusion of fluids and blood loss during surgery were similar in both groups.

Table 1. Clinical details of patients studied.

	Males: females	Age, years (SD)	Type of surgery, coronary: valve
Group A	5:5	53 (15.3)	3:7
Group B	7:3	45 (11.6)	2:8

We measured by direct radioimmunoassay (RIA) cortisol (Amersham kit), aldosterone (Sorin kit) and 11 de-oxycortisol (RSL kit) in all samples. Cross reactivity of antibodies to cortisol and 11 de-oxycortisol was negligible. Intra- and interassay coefficients of variation for all assays were less than 10 and 15% respectively. Statistical studies were analysed with the Mann–Whitney *U* test: a probability of less than 0.05 was considered significant.

Results

Etomidate 0.04 mg/kg produced slight sedation without loss of consciousness; surgery was uneventful in all cases; the results, expressed as mean (SD) are shown in Table 2.

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Table 2. Cortisol, aldosterone and 11 de-oxycortisol responses to ACTH. Results are expressed as mean (SD).

	Before injection with etomidate or thiopentone	Thirty minutes after first sample	Thirty minutes after second sample
Cortisol (*μmol/litre*)			
Group A	0.60 (0.30)	0.45 (0.25)	0.68 (0.25)
Group B	0.64 (0.23)	0.49 (0.26)	0.90 (0.39)
Statistical significance	NS	NS	$p < 0.05$
Aldosterone (*nmol/litre*)			
Group A	0.52 (0.51)	0.29 (0.18)	0.37 (0.21)
Group B	0.45 (0.33)	0.36 (0.43)	1.10 (0.62)
Statistical significance	NS	NS	$p < 0.01$
11 de-oxycortisol (*nmol/litre*)			
Group A	10.2 (3.5)	13.9 (9.6)	45.5 (17.7)
Group B	8.7 (2.6)	11.9 (3.5)	22.0 (15.4)
Statistical significance	NS	NS	$p < 0.05$

Peak cortisol and aldosterone levels were significantly lower in etomidate-treated patients, while 11 de-oxycortisol was clearly elevated after ACTH.

Discussion

Subanaesthetic doses of etomidate are able to inhibit adrenal 11-hydroxylase and blunt cortisol and aldosterone responses to ACTH in patients without adrenal disease. The apparently more evident effects on aldosterone concentrations may be because a number of patients had hyperaldosteronism secondary to their cardiac disease. Other drugs taken by some of these patients did not interfere with the results. Thiopentone *in vitro* at high doses can inhibit cortisol responses to ACTH,[11] but at the doses used during anaesthesia the response is normal.[2–6] Fentanyl at the high doses used in cardiac surgery suppresses hypophyseal ACTH release, but cortisol response to exogenous ACTH is normal.[13] The anti-adrenal effect of low doses of etomidate is probably short lived, although we have not studied it, since cortisol response to ACTH is normal 6 hours postoperatively when full anaesthetic doses of etomidate are used.[14]

These results agree with a preliminary communication of Allolio and colleagues,[15] who found that an infusion of etomidate at nonhypnotic doses of 2.5 mg/hour significantly reduced serum cortisol concentration, while 11 de-oxycortisol increased in five patients with Cushing's syndrome. Our study shows that this is also found in patients without adrenal disease. In conclusion etomidate is more potent as an anti-adrenal than hypnotic agent.

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References

1. Wagner RL, White PF, Kan PB, Rosenthal MH, Feldman D. Inhibition of adrenal steroidogenesis by the anesthetic etomidate. *New England Journal of Medicine* 1984; **310:** 1415–21.
2. Wagner RL, White PF. Etomidate inhibits adrenocortical function in surgical patients. *Anesthesiology* 1984; **61:** 647–51.
3. Fragen RS, Shanks CA, Molteni A, Avram MJ. Effects of etomidate on hormonal responses to surgical stress. *Anesthesiology* 1984; **61:** 652–6.
4. Fry DE, Griffiths H. The inhibition of etomidate of the 11 betahydroxylation of cortisol. *Clinical Endocrinology* 1984; **20:** 625–9.
5. Allolio B, Dorr H, Stuttmann R, Knorr D, Engelhard D, Winkelmann W. Effect of a single bolus of etomidate upon eight major corticosteroid hormones and plasma ACTH. *Clinical Endocrinology* 1985; **22:** 281–6.
6. Duthie DJR, Fraser R, Nimmo WS. Effect of induction of anaesthesia with etomidate on corticosteroid synthesis in man. *British Journal of Anaesthesia* 1985; **75:** 156–9.
7. Wanscher M, Tonnesen E, Huttel M, Larsen K. Etomidate infusion and adrenocortical function. A study in elective surgery. *Acta Anaesthesiologica Scandinavica* 1985; **29:** 483–5.
8. Mehta MP, Dillman JB, Sherman BM, Ghoneim MM, Lemke JH. Etomidate anesthesia inhibits the cortisol response to surgical stress. *Acta Anaesthesiologica Scandinavica* 1985; **29:** 486–9.
9. Moore RA, Allen MC, Wood PJ, Rees LH, Sear JW. Perioperative endocrine effects of etomidate. *Anaesthesia* 1985; **40:** 124–30.
10. De Coster R, Beerens D, Haelterman C, Wouters L. Effects of etomidate on cortisol biosynthesis in isolated guinea-pig adrenal cells: comparison with metyrapone. *Journal of Endocrinological Investigation* 1985; **8:** 199–202.
11 Lambert A, Frost J, Mitchell R, Robertson WR. On the assessment of the in vitro biopotency and site(s) of action of drugs affecting adrenal steroidogenesis. *Annals of Clinical Biochemistry* 1986; **23:** 225–9.
12. Van Hamme MJ, Ghoneim MM, Amber JJ. Pharmacokinetics of etomidate—a new intravenous anesthetic. *Anesthesiology* 1978; **49:** 274–7.
13 George JM, Reier CE, Lanese RR, Rower JM. Morphine anesthesia blocks cortisol and growth hormone response to surgical stress in humans. *Journal of Clinical Endocrinology and Metabolism* 1974; **38:** 736–41.
14. Crozier TA, Beck D, Schlaeger M, Wuttke W, Kettler D. Endocrinological changes following etomidate, midazolam or methohexital for minor surgery. *Anesthesiology* 1987; **66:** 628–35.
15. Allolio B, Kaulen D, Reincke M, Jaursch-Hancke C, Winkelmann W. Non-hypnotic low-dose etomidate for rapid correction of hypercortisolism (Abstract). *Acta Endocrinologica* 1987; **114** (Suppl. 283): 203–4.

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Propofol induction and maintenance with nitrous oxide in paediatric outpatient dental anaesthesia

A comparison with thiopentone–nitrous oxide–halothane

N. PUTTICK AND M. ROSEN

Summary

Intravenous induction of anaesthesia with propofol (3.5 mg/kg) and maintenance boluses (1 mg/kg), with 30% oxygen and 70% nitrous oxide, were compared with intravenous thiopentone induction (5 mg/kg) followed by 30% oxygen and 70% nitrous oxide, supplemented with 2 to 3% halothane in children aged 2–11 years who underwent dental extractions. Both techniques were found to be acceptable in clinical practice. Recovery from anaesthesia was assessed by the time taken to reach clinically-defined milestones. Times to open eyes, give name, stand unaided, and time to discharge were all 3 to 7 minutes shorter in those who had the propofol technique compared with those who had thiopentone–halothane ($p < 0.05$). These indices of recovery were more sensitive than the Steward score.

Key words

Anaesthesia; paediatric.
Recovery.

Prompt recovery from intravenous propofol (2,6-di-isopropylphenol in soya bean oil emulsion Diprivan, ICI Pharmaceuticals) has been considered advantageous for daycase anaesthesia.[1–3] Its use as an induction agent in paediatric anaesthesia has been described.[4] Outpatient dental surgery with general anaesthesia in children is usually of short duration and requires rapid recovery to facilitate both early, safe discharge and efficient turnover. Propofol has been used extensively in the authors' hospital, both for induction alone, and induction and maintenance of anaesthesia in this group. Clinical experience showed that 3.0–3.5 mg/kg propofol was required in unpremedicated children for induction and that intermittent boluses of 1 mg/kg, given in response to signs of light anaesthesia, were appropriate when 30% oxygen and 70% nitrous oxide were used. The standard technique before the introduction of propofol consisted of thiopentone 5 mg/kg for induction followed by halothane in 30% oxygen and 70% nitrous oxide. Spontaneous ventilation with a nasal mask is used for both techniques. This study compares the two techniques during anaesthesia and recovery.

Methods

Patients aged 2–11 years, ASA 1, admitted for daycase dental extractions under general anaesthesia, were allocated randomly into two groups. Patients underwent a routine pre-operative interview and examination in the presence of a parent; no premedication was administered. All patients were managed by a single anaesthetist. Anaesthesia was induced in the operating room according to customary practice, with the child either seated on a parent's lap (up to about 5 years of age) or supine on the operating table. Baseline blood pressure and heart rate were recorded if practicable. Venous access was secured with a 23-gauge cannula placed in a hand or wrist vein. It was not possible to blind the anaesthetic technique in the operating theatre.

Anaesthesia was induced in one group with thiopentone 5 mg/kg. The patient was transferred to the operating table after loss of consciousness, and inhalation of 30% oxygen with 70% nitrous oxide was started using a McKesson nasal mask and Mapleson A breathing system. Halothane was delivered with a calibrated vaporizer; the inspired concentration was increased rapidly to 5% then reduced according to response to a maintenance level, usually 2%.

Anaesthesia was induced in the other group with propofol 3.5 mg/kg to which lignocaine had been added (10 mg lignocaine to 200 mg propofol).[5] Inhalation of 30% oxygen with 70% nitrous oxide was started. The syringe that contained propofol was placed at a position conveniently close to the anaesthetist and connected to the cannula by an extension with a small deadspace. Maintenance was

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by incremental boluses of propofol 1 mg/kg administered according to each patient's motor, respiratory, and cardiovascular responses.

A soft latex nasopharyngeal airway was inserted if required. Pulse oximetry was used in all patients, and arterial pressure and heart rate measured with an automated noninvasive apparatus with a printer. Surgery, which involved a wide variety of operators and included students, started after jaw relaxation was sufficient to permit insertion of a dental prop. Oxygen 100% was administered for 2 minutes after completion of surgery, and the patient was turned on to the left side with a head-down tilt. Oxygen was then given by facemask and the patient was transferred to the first stage recovery room until conscious, cooperative, and able to maintain an airway, before being moved to a second stage general recovery area. The patient was at all times under the care of one or more of a group of six experienced recovery nurses who were unaware of the anaesthetic technique used. The following times were recorded; from the start of intravenous induction to loss of consciousness, to the start of surgery, and the duration of the procedure to the end of inhalation. The number of bolus increments of propofol administered, or maintenance concentration of halothane, was recorded. Quality of anaesthesia during induction was scored empirically as good, adequate, or poor, and any side effects noted. Surgical conditions and side effects during maintenance were assessed in similar fashion, and any movement during surgery noted. Timing and assessment during anaesthesia were performed by the anaesthetist.

A timer was started by the recovery staff at the end of inhalation. Recovery was assessed by the Steward scoring system,[6] which awards a score of 0, 1 or 2 points to each of three attributes: wakefulness, ventilation, and movement. The score is calculated at 3, 5, 15 and 30 minutes and at discharge from the recovery area; the range of possible scores at each time is 0 to 6. The times at which the patient was able to open the eyes spontaneously, give name when asked, and stand unaided were recorded. The incidence of crying and other side effects that occurred during recovery was noted. The time of discharge was that at which the anaesthetist confirmed the recovery nurse's assessment that the patient was fit to leave the hospital accompanied by the parent. The anaesthetist then gave appropriate postanaesthetic counselling. Statistical analysis was by Student's *t*-test, Fisher Exact test, or Mann–Whitney *U* test.

Results

Two patients in the propofol group were excluded from analysis after difficulty during the induction period which led to abandonment of protocol procedures. One developed intractable airway obstruction which required treatment with 100% oxygen and tracheal intubation; massive tonsillar hyperplasia was evident on laryngoscopy. The second developed laryngospasm, and also required 100% oxygen; this patient was later found to have had a previously undisclosed recent upper respiratory tract infection. Such events are common in this group regardless of anaesthetic technique used.

Anaesthesia (Table 1)

Table 1. Data collected during anaesthesia, presented as mean (SD), or number of patients.

	Thiopentone ($n = 20$)	Propofol ($n = 18$)
Age, years	6.1 (2.4)	5.1 (1.9)
Male: female ratio	11:9	7:11
Weight, kg	23.4 (7.0)	18.2 (4.2)
Extractions	4.6 (2.3)	6.3 (5.2)
Induction time, seconds	21 (4.2)	21 (3.5)
Number of apnoeas (mean duration)	5 (32 seconds)	2 (30 seconds)
Induction side effects	1	2
Quality of anaesthesia during induction	18 good 1 adequate 1 poor	17 good 1 adequate
Pain on injection	0	1
Induction to surgery interval, minutes	2.1 (0.6)	1.7 (0.6)
Duration, minutes	8.1 (3.7)	6.3 (3.1)
Propofol boluses	—	2.4 (1.3)
Halothane %, mean	2.15	—
Surgical response	2	8*
Surgical conditions	20 good	17 good 1 adequate

* $p < 0.05$.

Physiological parameters are not tabulated. Transient decreases in haemoglobin oxygen saturation to 95% or less were corrected rapidly by airway manipulation which included, in most instances, temporary cessation of surgery and insertion of a soft latex nasopharyngeal airway; in no case did the saturation decrease below 90%. Automated noninvasive arterial pressure measurement was used during maintenance in the majority of patients, but it was rarely possible to obtain a pre-induction baseline value and so little information could be obtained about cardiovascular stability. No disturbances of arterial pressure or heart rate which required clinical intervention were observed.

Mean induction times in both groups were identical at 21 seconds. The incidence of apnoea was higher in the thiopentone group, but the difference was not statistically significant. Side effects during induction were uncommon; one patient in each group exhibited movement, and one in the thiopentone group developed transient masseter spasm. The quality of anaesthesia during induction was assessed as good in all but one case in the propofol group and two in the thiopentone group. Pain on injection of induction agent occurred in only one patient, who received propofol (with added lignocaine). The times between induction and start of surgery, and the duration of procedure, were

Table 2. Data collected during recovery from anaesthesia, expressed as mean (SD), or number of patients.

	Thiopentone ($n = 20$)	Propofol ($n = 18$)
Mean Steward score at:		
3 minutes	0.2	0.8
5 minutes	1.2	2.6*
15 minutes	5.5	5.8
30 minutes	6	6
discharge	6	6
Time (minutes) to:		
Open eyes	10.7 (6.2)	7.7* (2.6)
Give name	18.8 (10.3)	13.2* (5.3)
Stand unaided	29.1 (11.3)	22.3* (8.1)
Discharge	43.5 (12.6)	36.4* (6.5)
Crying	10	9
Other side effects in recovery	15	11
Vomiting	0	0

* $p < 0.05$.

similar. Movement in response to surgery occurred significantly more often in the propofol (8 patients) than in the thiopentone (2 patients) group. However this did not affect surgical conditions adversely; these were assessed as good in all but one patient, who received propofol. The mean inspired concentration of halothane during maintenance in the thiopentone group was 2.15% (range 2 to 3%). The mean number of bolus increments in the propofol group was 2.4 (SD 1.2, range 0–5) which equated to a dose rate of 0.38 mg/kg/minute.

Recovery (Table 2, Figs 1 and 2)

All patients had attained a maximum Steward score of 6 by 30 minutes. The mean score for propofol patients was significantly higher at 5 minutes. The mean times taken to open eyes, give name, stand unaided, and to be assessed fit for discharge were all 3 to 7 minutes shorter after propofol ($p < 0.05$). The incidences of crying and other side effects, which included cough, flush, transient rash, headache, dizziness, and confusion, were similar in both groups.

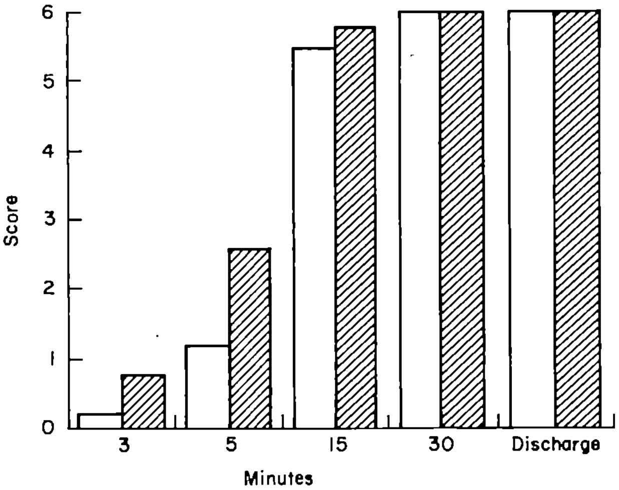

Fig. 1. Recovery after anaesthesia assessed by Steward score. □, thiopentone; ■, propofol.

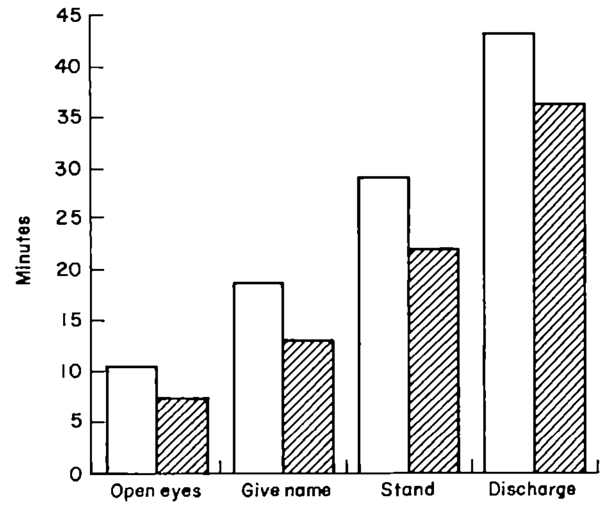

Fig. 2. Recovery after anaesthesic assessed by 'Milestones'. □, thiopentone; ■, propofol.

Discussion

Both techniques proved suitable for routine use by a single anaesthetist. However, some experience was required in the timing of bolus doses of propofol. Recovery to defined stages was significantly accelerated in the propofol group. However, the Steward score distinguished between the two groups only at 5 minutes. This is perhaps not surprising as Steward's scoring system was designed to assess the safe return of protective reflexes. There have been few attempts to apply formal psychomotor tests to recovery in children. The enhanced assessment of recovery provided by the simple measurement of time taken to achieve clinically relevant milestones suggests that this method is sensitive and deserves further investigation and validation.

The improvement of 3–7 minutes in rapidity of recovery represents an advantage in outpatient dental anaesthesia where the caseload is high. In particular, the enhancement of early recovery resulted in a less frequent need to keep a recovering patient in the operating theatre while the previous patient remained in the first stage recovery room.

The halothane technique involved delivery of an initially high, then a relatively steady inspired concentration until the end of surgery could be anticipated. The propofol technique required the incremental administration of bolus doses in response to signs of decreasing depth of anaesthesia. This is a common feature of intravenous anaesthetic techniques where a continuous infusion is not employed. It is therefore possible that the difference in recovery times could have been influenced by the depth of anaesthesia both during, and at the end of, the procedure. The higher incidence of intra-operative movement in the propofol group was considered to be related to this mode of administration. These limitations might be overcome by an infusion technique with a syringe pump. The mean rate of propofol bolus administration in this study, 0.38 mg/kg/minute, approximates to the ED_{95} infusion rate of 0.348 mg/kg/minute calculated from results obtained in adults premedicated with lorazepam.[7]

The incidence of pain on injection of propofol into hand veins has been estimated at 37.5.%[8] Addition of lignocaine to propofol in the stated proportion was approved by the manufacturers for the purpose of this study, and our results (5.6%) confirm other authors' experience.[5,9]

In summary, propofol with nitrous oxide provides conditions comparable to thiopentone with halothane and nitrous oxide for paediatric outpatient dental surgery.

Acknowledgments

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References

1. Noble J, Ogg TW. The effect of propofol ("Diprivan") and methohexitone on memory after day case anaesthesia (Abstract). *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 103–4.
2. McLeod B, Boheimer N. Propofol ("Diprivan") infusion as main agent for day case surgery. *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 105–7.
3. Kay B, Healy TEJ. Propofol ("Diprivan") for outpatient cystoscopy. Efficacy and recovery compared with Althesin and methohexitone. *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 108–14.

4. Purcell-Jones G, James IG. The characteristics of propofol ("Diprivan") for induction of general anaesthesia for paediatric surgery (Abstract). *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 115.
5. Redfern N, Stafford MA, Hull CJ. Incremental propofol for short procedures. *British Journal of Anaesthesia* 1985; **57**: 1178–82.
6. Steward DJ. A simplified scoring system for the post-operative recovery room. *Canadian Anaesthetists' Society Journal* 1975; **22**: 111–3.
7. Turtle MJ, Cullen P, Prys-Roberts C, Coates D, Monk CR, Faroqui MH. Dose requirements of propofol by infusion during nitrous oxide anaesthesia in man, II: Patients premedicated with lorazepam. *British Journal of Anaesthesia* 1987; **59**: 283–7.
8. McCulloch MJ, Lees NW. Assessment and modification of pain on induction with propofol (Diprivan). *Anaesthesia* 1985; **40**: 1117–20.
9. Brooker J, Hull CJ, Stafford M. Effect of lignocaine on pain caused by propofol injection *Anaesthesia* 1985; **40**: 91–92.

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Plasma bupivacaine concentrations during caudal analgesia and ilioinguinal–iliohypogastric nerve block in children

P. J. STOW, A. SCOTT, A. PHILLIPS AND J. B. WHITE

Summary

Plasma bupivacaine concentrations were measured in 27 children aged 3–7 years who received one of two analgesic regimens for herniotomy or orchidopexy. Analgesia was provided either by caudal epidural bupivacaine 0.2% 2 mg/kg ($n = 14$) or by ilioinguinal–iliohypogastric nerve block with bupivacaine 0.5% 1.25 mg/kg ($n = 13$). Mean (SD) peak venous bupivacaine concentrations were 0.57 (0.17) µg/ml and 0.79 (0.38) µg/ml respectively. Time to peak plasma concentrations were 29.6 (7.9) and 22.3 (10.9) minutes respectively. These concentrations are well below the potentially toxic level of 4.0 µg/ml, but suggest that uptake of bupivacaine is more rapid after ilioinguinal–iliohypogastric nerve block than during caudal analgesia.

Key words

Anaesthetics, local; bupivacaine.
Anaesthetic techniques, regional; ilioinguinal–iliohypogastric nerve block.

Bupivacaine is used extensively in paediatric anaesthetic practice to provide intra- and postoperative analgesia of long duration. It has been shown to provide adequate postoperative analgesia when used for ilioinguinal–iliohypogastric nerve block[1,2] or caudal analgesia[3,4] although its use may result in high plasma concentrations.[5] Plasma concentrations greater than 4.0 µg/ml are potentially toxic[6–8] and a knowledge of potential plasma bupivacaine concentrations during regional analgesia is desirable. Bupivacaine concentrations have been measured during caudal analgesia,[5,9,10] lumbar epidural analgesia,[11] intercostal nerve block,[12] axillary block[13] and subcutaneous injection[9] in children, but they have not been measured following ilioinguinal–iliohypogastric nerve block. This study was designed to measure plasma bupivacaine concentrations after caudal analgesia and ilioinguinal–iliohypogastric nerve block in children.

Methods

Patients and anaesthesia

Twenty-seven children were studied with the approval of the hospital ethics committee. All children were ASA grade 1 or 2 and were admitted to hospital for elective inguinal herniotomy or orchidopexy. All children and parents were interviewed before operation and the local anaesthetic procedures were explained. Each child was premedicated with trimeprazine syrup 3 mg/kg orally 90 minutes before surgery. Anaesthesia was induced with intravenous sodium thiopentone 5–6 mg/kg, and was maintained by spontaneous ventilation of nitrous oxide 66% in oxygen supplemented by enflurane. After induction of anaesthesia, the local anaesthetic block was performed by one of the authors.

Children who received caudal analgesia were placed in the lateral position and the skin over the sacrum was cleaned with chlorhexidine. The sacral cornua were identified and the sacrococcygeal membrane was pierced with a 30 mm 23-gauge needle by means of an aseptic technique with gloved hands. Negative aspiration for blood or cerebrospinal fluid, and the injection of 5 ml of air, confirmed correct placement in the caudal extradural space and bupivacaine 0.2% 2 mg/kg was injected over 20–30 seconds. Bupivacaine 0.2% was prepared by the anaesthetist, by the dilution of bupivacaine 0.25% with 0.9% sodium chloride solution.

Ilioinguinal–iliohypogastric nerve block was performed after the skin had been cleaned locally with chlorhexidine; using a short-bevelled 25-gauge needle, bupivacaine 0.5% 1.25 mg/kg was injected at a point 2 cm medial and inferior to the anterior superior iliac crest, as recommended by von Bahr.[14]

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Plasma bupivacaine concentration

A 20-gauge cannula was inserted into a forearm vein, after the induction of anaesthesia and used solely for the aspiration of blood samples for bupivacaine assay. Venous blood samples (2 ml) were collected following aspiration of fluid from the deadspace of the cannula. Blood was sampled immediately before injection of the local anaesthetic solution and at 5, 10, 15, 20, 30, 45 and 60 minutes afterwards. Samples were placed in heparinised tubes, centrifuged to yield 1 ml of plasma and stored immediately at −20°C. Bupivacaine concentrations were assayed subsequently by high pressure liquid chromatography (HPLC) using reverse phase HPLC with ultraviolet detection. Assays were performed by an independent biochemist who was blinded to the local anaesthetic procedure. All plasma concentrations were expressed as μg/ml of bupivacaine hydrochloride. The lower limit of detection of bupivacaine was 0.05 μg/ml.

Statistical analysis

Student's unpaired *t*-test was used to compare the demographic data and the bupivacaine concentrations. Statistical significance was accepted as $p < 0.05$. All data are expressed as mean (SD).

Results

Patients

The demographic data for the 27 children are shown in Table 1. Fourteen children received caudal bupivacaine and 13 received ilioinguinal–iliohypogastric nerve block. There were no significant differences between the groups in terms of age, weight or sex. Analgesia was satisfactory in both groups; only one child in the caudal group and two in the ilioinguinal group required postoperative analgesia. There were no clinical signs of bupivacaine toxicity.

Table 1. Patient demographic data. Values expressed as mean (SD).

	Caudal 0.2% $n = 14$	Ilioinguinal–iliohypogastric 0.5% $n = 13$
Age, years	4.84 (1.63)	5.21 (1.64)
Weight, kg	18.70 (4.97)	19.89 (6.24)

Bupivacaine concentrations

Mean plasma bupivacaine concentrations at 5, 10, 15, 20, 30, 45 and 60 minutes after injection of the local anaesthetic are shown in Table 2. The mean bupivacaine concentrations plotted against time for the caudal and ilioinguinal–iliohypogastric groups are shown in Fig. 1. A significant difference between the two groups ($p < 0.05$) was found at 45 minutes after insertion of the block. The peak plasma concentrations of 0.57 (0.17) μg/ml for the caudal group and 0.79 (0.38) μg/ml for the ilioinguinal–iliohypogastric group were reached in 29.6 (7.9) and 22.3 (10.9) minutes respectively.

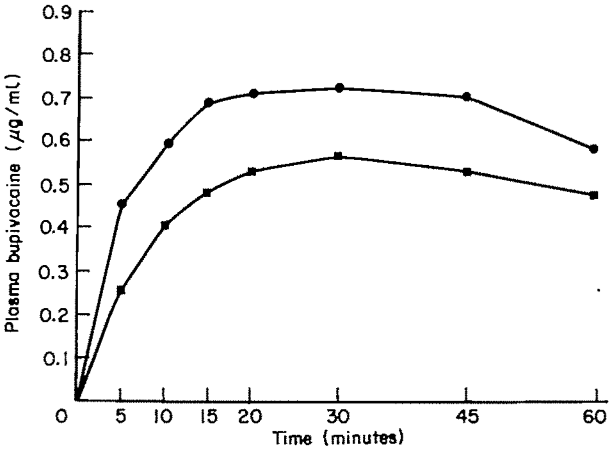

Fig. 1. Mean plasma bupivacaine concentrations after: ●, ilioinguinal–iliohypogastric nerve block; ■, caudal injection.

Discussion

We have demonstrated that the use of bupivacaine 0.2% 2 mg/kg for caudal injection, or 0.5% 1.25 mg/kg for ilioinguinal–iliohypogastric nerve block results in venous plasma bupivacaine concentrations in children of less than 2.0 μg/ml. These concentrations are considerably less than 4.0 μg/ml, which is generally accepted as a safe maximum plasma concentration.[7,8,12,13,15] The published 'safe' plasma levels depend on several factors. Arterial plasma concentrations may be up to 30% greater than venous levels measured simultaneously,[8,10,12] which suggests that there is active pulmonary uptake and subsequent release of bupivacaine by the lung into the systemic circulation. Pulmonary uptake and release of bupivacaine have been demonstrated both clinically and experimentally.[16,17] Venous concentrations are greater than arterial during uptake, which is rapid for bupivacaine. This is followed by a more prolonged period of release, when arterial concentrations are greater than venous. We measured venous plasma concentrations in this study, as serial arterial sampling was felt to be too invasive and could not be justified.

The safe maximum concentration depends also on whether bupivacaine concentrations are assayed in whole blood or in plasma. Tucker and Mather[18] reason that peripheral tissues are exposed to drug in whole blood, and not in plasma alone; it may therefore be more rational to assay bupivacaine in whole blood. The whole blood:plasma concentration ratio (λ) has been reported as 0.73 in adults,[19]

Table 2. Mean plasma bupivacaine concentrations (μg/ml) after injection. Values expressed as mean (SD).

Minutes	5	10	15	20	30	45	60
Caudal,	0.25	0.40	0.48	0.52	0.56	0.52	0.47
$n = 14$	(0.12)	(0.12)	(0.14)	(0.16)	(0.18)	(0.15)	(0.14)
Ilioinguinal,	0.46	0.59	0.69	0.71	0.72	0.70	0.58
$n = 13$	(0.42)	(0.44)	(0.38)	(0.34)	(0.35)	(0.27)	(0.22)

and 0.47–0.82 in children; the values vary inversely with haematocrit.[12]

Tucker and Mather[18] have stated that moderate signs of toxicity develop during intravenous infusion of bupivacaine when the whole blood concentration reaches 1.0–1.6 μg/ml. A whole blood concentration of 1.6 μg/ml corresponds to a venous plasma concentration of 2.2 μg/ml, and an arterial plasma concentration of 2.8 μg/ml. However, these values may be too conservative. There is less time for binding and redistribution during rapid intravenous administration, and there is a greater fraction of free or unbound drug. Toxic effects develop at lower plasma concentrations than during the slow administration of a similar total dose.[7] Furthermore, there is evidence to suggest that the safe maximum plasma concentration may be higher than 4.0 μg/ml.[15] General anaesthesia and central nervous system depressants raise the threshold to the toxic effects of local anaesthetic drugs. Neill and Watson[20] found no clinical evidence of toxicity during general anaesthesia in adults despite plasma bupivacaine concentrations of up to 6.0 μg/ml.

Previous studies have measured bupivacaine concentrations after caudal analgesia in children. Eyres *et al.*[9] used bupivacaine 0.5% 2.1 mg/kg, and found mean peak concentrations of less than 1.1 μg/ml 20 minutes after block insertion. The mean peak plasma concentration of 0.57 μg/kg in our study was reached at approximately 30 minutes; this lower concentration is probably related to the use of a lower concentration, although a similar total dose (2 mg/kg), of bupivacaine. Eyres *et al.*[10] measured a mean peak plasma concentration of 1.4 μg/ml in a further study in which bupivacaine 0.25% 3 mg/kg was used; this concentration was similar to that of 1.6 μg/ml reported by Armitage[5] after bupivacaine 0.25% 3.1 mg/kg. These values remain substantially below potentially toxic concentrations, even after allowance is made for a 30% greater value in arterial concentrations.

Recommended doses of bupivacaine for ilioinguinal–iliohypogastric nerve block vary considerably. Shandling and Steward[1] used bupivacaine 0.5% up to 2 mg/kg, whilst Smith and Jones[2] recommend up to 2.5 mg/year of age. Plasma bupivacaine concentrations have not been assayed after this block in previous studies, although Eyres *et al.*[9] measured peak concentrations of less than 1.0 μg/ml after the subcutaneous groin injection of bupivacaine 0.5% 2 mg/kg. One patient in the current study, whose data are not included in the results, received bilateral ilioinguinal–iliohypogastric nerve blocks with 0.25% 2 mg/kg; the peak plasma concentration was 0.98 μg/ml, well within safe limits.

The rate of increase in plasma bupivacaine concentration, as demonstrated by the time to peak plasma levels, was significantly greater after ilioinguinal–iliohypogastric nerve block. The rate of absorption may be related to four factors: the vascularity of the injected area, the ratio of the injected volume to the volume of the space into which injection is made, the concentration of local anaesthetic used, and the total dose of drug injected. The caudal epidural space is not a particularly vascular area and plasma uptake has been shown to be slower than from other areas, such as the axilla.[19] Furthermore, the caudal epidural space has a large volume compared to the relatively confined fascial planes which are separated under pressure during injection for ilioinguinal–iliohypogastric nerve block. We did not use comparable doses for each group in this study; had we done so, it is likely that peak venous plasma levels would have been even greater in patients who underwent ilioinguinal–iliohypogastric nerve block. We chose our local anaesthetic regimens for two reasons. Firstly, although bupivacaine 0.25% 2.5 mg/kg has been recommended for caudal analgesia in children,[5] we felt that it was unwise to use more than the maximum recommended dose of 2 mg/kg. There is always the risk of accidental intraosseous, intravascular or intrathecal injection, although plasma bupivacaine concentrations may remain below potentially toxic levels during properly conducted caudal analgesia. Secondly, the use of bupivacaine 0.5% 2 mg/kg for ilioinguinal–iliohypogastric nerve block would have resulted in the injection of an excessively large volume.

In summary, bupivacaine 0.2% 2.0 mg/kg for caudal analgesia or bupivacaine 0.5% 1.25 mg/kg for ilioinguinal–iliohypogastric nerve block produced effective analgesia and resulted in peak venous plasma bupivacaine concentrations below toxic levels in children.

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References

1. Shandling B, Steward DJ. Regional analgesia in postoperative pain in pediatric outpatient surgery. *Journal of Pediatric Surgery* 1980; **15:** 477–80.
2. Smith BAC, Jones SEF. Analgesia after herniotomy in a paediatric day unit. *British Medical Journal* 1982; **285:** 1466.
3. Kay B. Caudal block for postoperative pain relief in children. *Anaesthesia* 1974; **29:** 610–4.
4. Lunn JN. Postoperative analgesia after circumcision. A randomised comparison between caudal analgesia and intramuscular morphine in boys. *Anaesthesia* 1979; **34:** 552–4.
5. Armitage EN. Caudal block in children. *Anaesthesia* 1979; **34:** 396.
6. Jorfeldt L, Lofstrom B, Pernow B, Persson B, Wahren J, Widman B. The effect of local anaesthetics on the central circulation and respiration in man and dog. *Acta Anaesthesiologica Scandinavica* 1968; **12:** 153–69.
7. Scott DB. Evaluation of the toxicity of local anaesthetic agents in man. *British Journal of Anaesthesia* 1975; **47:** 56–61.
8. Moore DC, Balfour RI, Fitzgibbons D. Convulsive arterial plasma levels of bupivacaine and the response to diazepam therapy. *Anesthesiology* 1979; **50:** 454–6.
9. Eyres RL, Kidd J, Oppenheim R, Brown TCK. Local anaesthetic plasma levels in children. *Anaesthesia and Intensive Care* 1978; **6:** 243–7.
10. Eyres RL, Bishop W, Oppenheim RC, Brown TCK. Plasma bupivacaine concentrations in children during caudal epidural analgesia. *Anaesthesia and Intensive Care* 1983; **11:** 20–2.
11. Eyres RL, Hastings C, Brown TCK, Oppenheim RC. Plasma bupivacaine concentrations following lumbar epidural anaesthesia in children. *Anaesthesia and Intensive Care* 1986; **14:** 131–4.
12. Rothstein P, Arthur FR, Feldman HS, Kopf GS, Covino BG. Bupivacaine for intercostal nerve blocks in children: blood concentrations and pharmacokinetics. *Anesthesia and Analgesia* 1986; **65:** 625–32.
13. Campbell RJ, Ilett KF, Dusci L. Plasma bupivacaine concentrations after axillary block in children. *Anaesthesia and Intensive Care* 1986; **14:** 343–6.

14. von Bahr V. Local anaesthesia for inguinal herniorrhaphy. In: Erikkson E, ed. *Illustrated handbook of local anaesthesia.* London: Lloyd-Luke, 1979; 52–4.
15. Mather LE, Long GJ, Thomas J. The intravenous toxicity and clearance of bupivacaine in man. *Clinical Pharmacology and Therapeutics* 1971; **12:** 935–43.
16. Moore DC, Mather LE, Bridenbaugh PO, Bridenbaugh LD, Balfour RI, Lysons DF, Horton WG. Arterial and venous plasma levels of bupivacaine following epidural and intercostal nerve blocks. *Anesthesiology* 1976; **45:** 39–45.
17. Jorfeldt L, Lewis DH, Löfstrom JB, Post C. Lung uptake of lidocaine in healthy volunteers. *Acta Anaesthesiologica Scandinavica* 1979; **23:** 567–74.
18. Tucker GT, Mather LE. Pharmacokinetics of local anaesthetic agents. *British Journal of Anaesthesia* 1975; **47:** 213–24.
19. Tucker GT, Mather LE. Clinical pharmacokinetics of local anaesthetics. *Clinical Pharmacokinetics* 1979; **4:** 241–78.
20. Neill RS, Watson R. Plasma bupivacaine concentrations during combined regional and general anaesthesia for resection and reconstruction of head and neck carcinomata. *British Journal of Anaesthesia* 1984; **56:** 485–91.

Anaesthesia, 1988, Volume 43, pages 654–658

CASE REPORT

Tracheal stenosis or agenesis in association with tracheo-oesophageal fistula and oesophageal atresia

R. J. BRAY AND W. H. LAMB

Summary

Two babies are described with oesophageal atresia, a tracheo–oesophageal fistula and severe subglottic tracheal stenosis. A third baby, who did not survive, had a tracheal agenesis associated with bronchi arising from the oesophagus. A review of the types of tracheal stenosis and agenesis associated with various forms of tracheo-oesophageal fistula is included.

Key words

Surgery; paediatric.
Intubation; trachea.

A baby who fails to cry or breathe after delivery in spite of vigorous respiratory movements may have an obstructed or absent trachea. This is often associated with a tracheo–oesophageal fistula which may assist in keeping the baby alive. The ultimate outcome, however, depends upon the severity of the tracheal abnormality.

Case histories

First patient

An eight-hour-old male baby was admitted to hospital with a diagnosis of oesophageal atresia and tracheo–oesophageal fistula. The pregnancy had been uneventful and the baby, who weighed 2.6 kg, had been delivered normally at term. He appeared to be mildly asphyxiated but improved when given oxygen with a facemask. He was later noticed to be 'mucousy' and a feeding tube passed nasally was seen on the chest X ray to be coiled in the upper oesophagus. Intestinal gas was also seen on the X ray and a diagnosis made of oesophageal atresia and lower oesophageal pouch tracheo–oesophageal fistula. The umbilical cord was noted to have only two vessels but in other respects the baby appeared to be normal.

The baby's breathing seemed normal but after transfer to the operating theatre it proved impossible to pass a tracheal tube below the vocal cords. Eventually, the trachea was intubated with a 16-G venous cannula and anaesthesia was induced; a tracheostomy was performed without further difficulty. Subsequently a small upper pouch tracheo–oesophageal fistula was found as well as the anticipated oesophageal atresia and lower pouch fistula. The two fistulae were divided and a primary oesophageal anastomosis was made.

Postoperative recovery was unremarkable and a direct laryngoscopy 11 days later revealed a narrow, apparently cartilaginous, subglottic stenosis. This stenosis did not respond to a series of dilatations, and at the age of 2 years the child underwent a laryngotracheopexy with the insertion of a rib graft. This has not yet produced a satisfactory upper airway and he still retains his tracheostomy 18 months later.

Second patient

This male 38-week gestation baby, who weighed 2.25 kg, had a normal delivery after a pregnancy complicated by maternal hypertension. The baby required immediate resuscitation and was 'intubated' with a 2.5 mm tracheal tube. A diagnosis of oesophageal atresia was made after failure to pass a feeding tube into his stomach; he was transferred to the Children's Hospital at 11 hours old.

The baby appeared to be breathing normally on admission but at induction of anaesthesia it proved impossible to pass even a 2.5 mm tracheal tube beyond the vocal cords. A tracheostomy was performed under local analgesia and a 3.5 mm tracheostomy tube inserted without difficulty; general anaesthesia was started. Subsequently a lower pouch tracheo–oesophageal fistula was divided and a primary oesophageal anastomosis was carried out. Eight

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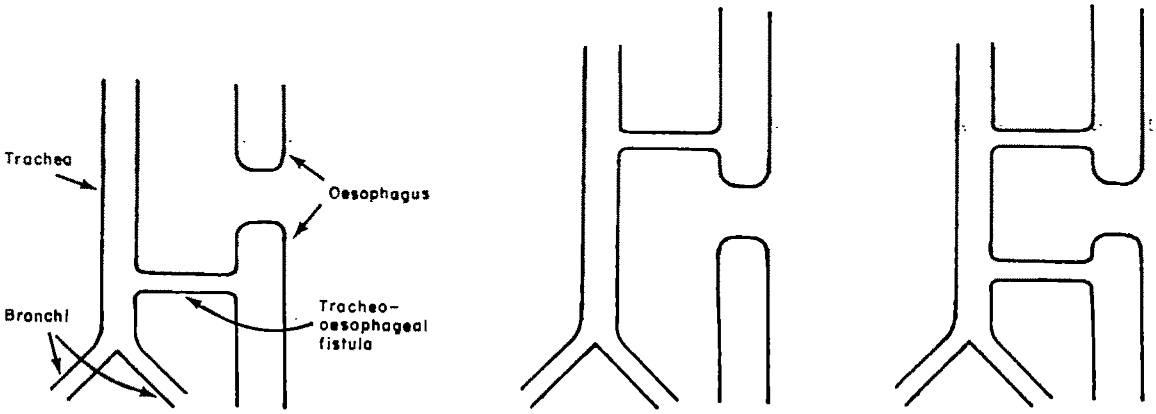
days after the operation a direct laryngoscopy revealed a narrow subglottic stenosis which it was thought would not respond to dilatation. The child is now aged 15 months and still retains his tracheostomy.

Third patient

A severely asphyxiated male baby who weighed 1.74 kg was born by an assisted breech delivery. The pregnancy had lasted 35 weeks and been complicated by polyhydramnios from the 32nd week. The baby improved with resuscitation using a facemask, but when intubation was attempted a 3.0-mm tracheal tube could not be passed into the trachea. The larynx itself appeared to be small and placed anteriorly. A later intubation attempt with a 2.5-mm tube also failed and ventilation was continued with a facemask. External examination revealed no abnormality apart from a prominent larynx and low set ears.

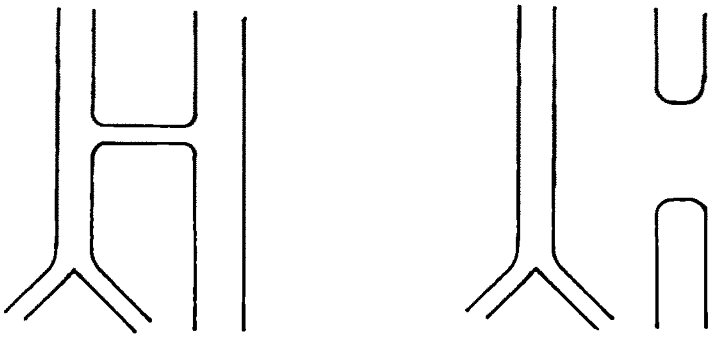
The baby continued to improve and started to breathe spontaneuously, but became cyanosed when a nasogastric



Oesophageal atresia with a lower pouch fistula (86%)

Oesophageal atresia with an upper pouch fistula (1%)

Oesophageal atresia with upper and lower pouch fistula (< 1%)



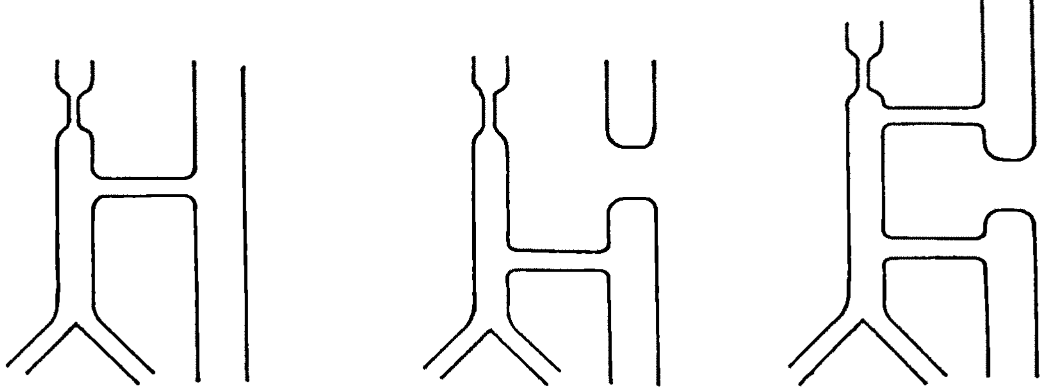
'H-type' tracheo-oesophageal fistula (5%)

Oesophageal atresia without a tracheo-oesophageal fistula (8%)

Fig. 1. Varieties of oesophageal atresia and tracheo-oesophageal fistula.

Without oesophageal atresia

With oesophageal atresia



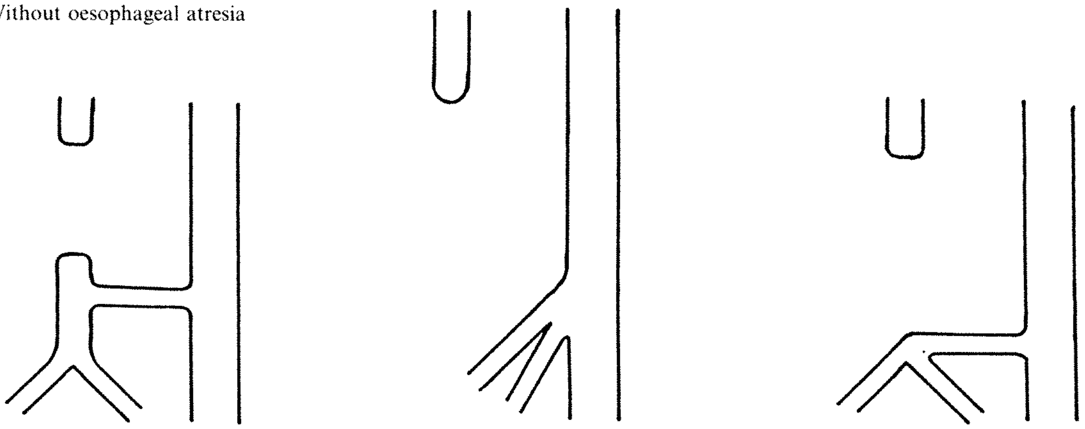
'H-type' fistula with sub-glottic tracheal stenosis[1,2] (eight cases)

Case 2: Oesophageal atresia with a lower pouch fistula and sub-glottic tracheal stenosis[3–6] (two cases)

Case 1: Oesophageal atresia with upper and lower pouch fistula and subglottic tracheal stenosis (one case)

Fig. 2. Varieties of tracheal stenosis and tracheo-oesophageal fistula.

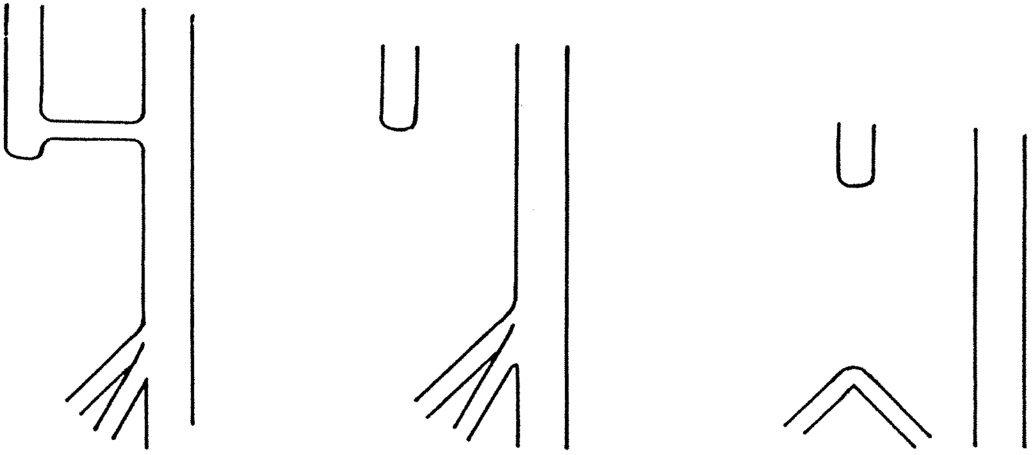
Without oesophageal atresia



Central tracheal agenesis with a lower tracheo-oesophageal fistula[7–10] (five cases)

Case 3: Agenesis of lower trachea with the bronchi arising separately from the oesophagus[9,25] (three cases)

Agenesis of lower trachea with a fistula between the carina and the oesophagus[7,9,11–19] (14 cases)



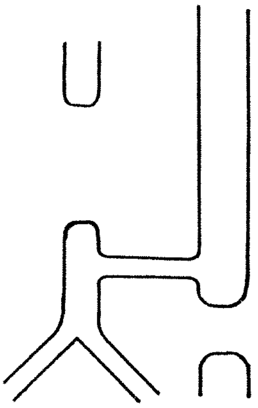
Lower tracheal agenesis with the bronchi arising separately from the oesophagus and a fistula between the upper trachea and the oesophagus[26] (one case)

Agenesis of lower trachea with the carina arising from the oesophagus[8,20–24] (seven cases)

Lower tracheal agenesis[27] (one case)

Fig. 3. Varieties of tracheal agenesis and tracheo-oesophageal fistula.

With oesophageal atresia



Central tracheal agenesis with oesophageal atresia and a fistula between the upper oesophageal pouch and the lower part of the trachea[28] (1 case)

Fig. 4. Tracheal agenesis and tracheo-oesophageal fistula.

tube was passed to decompress the stomach, which suggested that all the ventilation was through the oesophagus.

A diagnosis of tracheal agenesis was made and the neck was explored surgically in the hope of finding a tracheal remnant high enough to allow a tracheostomy to be fashioned. No tracheal structures were found however and the baby died some 6 hours after delivery. Postmortem examination confirmed the tracheal agenesis; the larynx ended blindly in a mass of cartilage and both main bronchi arose separately from the oesophagus. There was also a completely anomalous sub-diaphragmatic pulmonary venous drainage system.

Discussion

These children are examples of a rare complex of congenital abnormalities which involve the trachea and oesophagus. The varieties of oesophageal atresia and tracheo-oesophageal fistula are well known and are relatively common (1 in 3000–3500 live births Fig. 1). The much rarer abnormalities of congenital tracheal stenosis and agenesis can be added to this list. The types described in the literature to date can be classified in terms of whether oesophageal atresia is present, whether the trachea is merely narrowed or is completely absent for part or all of its length, and the number and levels of tracheo-oesophageal fistulae (Figs 2–4). Only rarely is a tracheo-oesophageal fistula absent.[27] It is possible that new variations may be described in the future.

The general clinical features of these babies may be outlined from the three cases described and the other cases reported in the literature. Polyhydramnios is a common finding during pregnancy [1,3–5,7,9,13,15,17,18,20,22,23,26,28] and is not limited to those variations which have oesophageal atresia.[1,7,9,13,15,17,18,20,22,23,26] Immediate respiratory distress is evident, after delivery,[1–5,7–28] often with vigorous respiratory efforts,[8] but with little or no gas exchange. There is no audible cry.[3,4,10,11,28] Failure to intubate the trachea much below the vocal cords is frequently,[1–5,8,9,12–14,16–20,22–25,28] but not invariably, reported.[6,9,11,23] Apparently successful intubation, like that described in our second patient, may be explained by a failure to appreciate that the tracheal tube has only reached a short distance below the cords or that the tube has passed into the oesophagus. Ventilation may be improved with a bag and facemask[3,8,21,23,28] or even by deliberate oesophageal intubation.[1,2,8–12,22,23,25,28] The gas in these cases passes through the oesophagus, or upper oesophageal pouch, to the lungs either directly or through a fistula.

The outcome in cases where the trachea is missing for all or part of its length has been invariably fatal, although operations where a length of oesophagus is isolated and used to fashion a 'tracheostomy' have prolonged life for a short period.[12,18,21] The only long term survivors have been some babies with a subglottic tracheal stenosis where a conventional tracheostomy has been made.[13] Later subglottic reconstructions have been carried out successfully in two of these cases.[1]

Clinical management

It is possible to suggest a plan for the diagnosis and early management of these babies from the three cases described and the review of the literature. The clinical diagnosis is suggested by maternal polyhydramnios followed by the baby's immediate respiratory distress after delivery, especially if this is accompanied by vigorous respiratory movements and the absence of an audible cry. The diagnosis is confirmed by the inability to pass a tracheal tube a significant distance below the vocal cords and, in the more severe forms, by a failure to produce much, if any, improvement with ventilation of the lungs through the tube. The tracheal tube should be withdrawn if ventilation is unsatisfactory and an attempt made to ventilate the baby's lungs with a facemask. The oesophagus should be intubated if this also fails and the position of the tube varied until adequate ventilation is achieved.

A more reliable airway will be provided by a tracheostomy and the baby's neck should be palpated to see whether a trachea is present; a tracheostomy should be performed as soon as possible if a trachea is felt. If it cannot be felt it is unlikely that the baby will survive. However, if adequate ventilation can be continued the anatomy should be confirmed by a contrast study through the oesophagus, although this carries a risk of the baby's deterioration.

Conclusions

Congenital subglottic stenosis and tracheal agenesis, are rare conditions often found in association with a tracheo–oesophageal fistula and, less commonly, with oesophageal atresia. They can be recognised clinically, and in their less severe forms can be managed successfully by the performance of an early tracheostomy. Later it may be possible to reconstruct a narrowed trachea.

Acknowledgments

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References

1. Leiberman A, Bar-Ziv J, Karplus M, Mares A, Weiss-shmidek Z. Subglottic laryngeal atresia associated with tracheoesophageal fistula. *Clinical Pediatrics* 1985; **24:** 523–5.
2. Peison B, Levitzky E, Sprowls JJ. Tracheoesophageal fistula associated with tracheal atresia and malformation of the larynx. *Journal of Pediatric Surgery* 1970; **5:** 464–7.
3. Sankaran K, Bhagirath CP, Bingham WT, Hjertaas R, Haight K. Tracheal atresia, proximal esophageal atresia, and distal tracheoesophageal fistula: report of two cases and review of literature. *Pediatrics* 1983; **71:** 821–3.
4. Sayre JW, Hall EG. Anomalies of the larynx associated with tracheo-oesophageal fistula. *Pediatrics* 1954; **13:** 150–3.
5. Ashley DJB. A case of congenital tracheal obstruction with oesophageal atresia. *Journal of Pathology* 1972; **108:** 261–3.
6. Hannallah R, Rosales JK. Laryngeal web in an infant with tracheoesophageal fistula. *Anesthesiology* 1975; **42:** 96–7.
7. Hopkinson JM. Congenital absence of the trachea. *Journal of Pathology* 1972; **107:** 63–7.
8. Lyons SM, Bruce AEG. Tracheal agenesis. A report of two cases. *Anaesthesia* 1968; **23:** 98–102.
9. Effmann EL, Spackman TJ, Berdon WE, Kuhn JP, Leonidas JC. Tracheal agenesis. *American Journal of Roentgenology* 1975; **125:** 767–81.
10. Sandison AT. Partial absence of the trachea with live birth. *Archives of Disease in Childhood* 1955; **30:** 475–7.
11. Hong SW, Baran GM, Schnaufer L, Stool SE. Tracheal agenesis with broncho–esophageal fistula. *Laryngoscope* 1973; **83:** 250–4.
12. Buchino JJ, Meagher DP, Cox JA. Tracheal agenesis: A clinical approach. *Journal of Pediatric Surgery* 1982; **17:** 132–7.
13. McCracken AW, Flanagan N, Flanagan P. Tracheal atresia associated with cor biloculare. *Thorax* 1964; **19:** 530–2.
14. Joshi VV. Tracheal agenesis *American Journal of Diseases of Children* 1969; **117:** 341–3.
15. Kessel I, Smith JN. Congenital absence of the trachea. *Thorax* 1953; **8:** 266–8.
16. Devenis AM, Otis RD. Tracheal atresia associated with tracheoesophageal fistula. *Journal of Thoracic Surgery* 1957; **34:** 405–8.
17. Witzleben CL. Aplasia of the trachea. *Pediatrics* 1963; **32:** 31–5.
18. Altman RP, Randolph JG, Shearin RB. Tracheal agenesis: recognition and management. *Journal of Pediatric Surgery* 1972; **7:** 112–8.
19. Warfel KA, Schulz DM. Agenesis of the trachea. Report of a case and review of the literature. *Archives of Pathology and Laboratory Medicine* 1976; **100:** 357–9.
20. Siplovich L, Cywes S. Tracheal agenesis. *Zeitschrift fur Kinderchirurgie* 1982; **35:** 12–3.
21. Fonkalsrud EW, Martelle RR, Maloney JV. Surgical treatment of tracheal agenesis. *Journal of Thoracic and Cardiovascular Surgery* 1963; **45:** 520–5.

22. Morgan CL, Grossman H, Leonidas J. Roentgenographic findings in a spectrum of uncommon tracheo–oesophageal anomalies. *Clinical Radiology* 1979; **30**: 353–8.
23. Faro RS, Goodwin CD, Organ CH, Hall RT, Holder TM, Ashcraft KW, Amoury RA. Tracheal agenesis. *Annals of Thoracic Surgery* 1979; **28**: 295–9.
24. Marek JJ. Congenital deformity of trachea. *Ohio State Medical Journal* 1940; **36**: 1308.
25. Floyd J, Campbell DC, Dominy DE. Agenesis of the trachea. *American Review of Respiratory Diseases* 1962; **86**: 557–60.
26. McNie DJM, Pryse -Davies J. Tracheal agenesis. *Archives of Disease in Childhood* 1970; **45**: 143–4.
27. Payne WA. Congenital absence of the trachea. *Brooklyn Medical Journal* 1900; **14**: 568.
28. Alfery DD, Ward CF, Plumer MH, Lynch F. Management of tracheal atresia with tracheoesophageal fistula. *Anesthesiology* 1980; **53**: 242–4.

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CASE REPORT

Pre-eclampsia in a parturient with a history of myocardial infarction

A case report and literature review

P. J. DAWSON AND A. W. ROSS

Summary

A mother with pre-eclamptic toxaemia and severe coronary artery disease was managed with epidural analgesia accompanied by invasive cardiovascular monitoring. Caesarean section was carried out uneventfully using the epidural. The literature is reviewed.

Key words

Pregnancy; eclampsia.
Heart; disease.

Pregnancy complicated by ischaemic heart disease is rare. There are a number of reports of acute myocardial infarction during pregnancy and the puerperium, but pregnancy after infarction has only been reported in the world literature on 19 occasions.[1–5] We report the management of a pregnancy after an acute myocardial infarction complicated by poor left ventricular function, triple vessel disease and pre-eclampsia. Delivery of the baby was by Caesarean section under epidural anaesthesia.

Case history

A 37-year-old patient with a history of ischaemic heart disease presented at 10 weeks' gestation for the management of her fourth pregnancy. She had suffered an inferior myocardial infarct 7 years before and an episode of crescendo angina one month after the infarction prompted therapy with beta blockers. Angiography at this time revealed right coronary artery stenosis. She was asymptomatic, receiving treatment with verapamil 40 mg three times a day until 3 weeks before this pregnancy, when she developed an 8-day episode of crescendo angina. Review angiography revealed triple vessel disease with an occluded right coronary and stenotic left anterior descending and circumflex arteries. Cardiac catheter studies indicated inferior hypokinesis and an ejection fraction of 0.44. An ECG stress test was performed but terminated because of leg pain at low work levels. Her risk factors were a history of smoking, essential hypertension, prolonged use of oral contraceptives, a positive family history and hypercholesterolaemia. The latter was diagnosed on her recent admission.

Other medical problems were asthma and a subtotal stenosis of the left subclavian artery. Her current maintenance therapy was verapamil 80 mg three times daily, glyceryl trinitrate paste 1 cm four times daily, aspirin 150 mg daily, prazosin 0.5 mg three times daily, cyclopenthiazide 0.5 mg mané and a salbutamol inhaler. The past three pregnancies had all been uneventful, the last, nine years previously. A fourth heart sound, right brachial blood pressure of 140/70 mmHg and grade 2 hypertensive retinopathy were detected on examination, but there was no evidence of left ventricular failure. Counselling with regard to the risks of continuation of the pregnancy was undertaken but the patient wished to proceed.

A multidisciplinary approach which involved cardiology, anaesthetic and obstetric staff was used. Aspirin therapy was ceased and antihypertensives were continued. Ultrasound confirmed dates and her antenatal course was uneventful until 30 weeks. Two weeks of generalised oedema, decreased exercise tolerance, and poor blood pressure control, which required increasing oral medication, prompted admission. Her arterial blood pressure was 230/130 mmHg, but settled to 170/90 mmHg. There was no proteinuria or hyperreflexia. Her uric acid was elevated to 0.4 mmol/litre and other maternal and fetal investigations were normal.

Her arterial pressures remained elevated at 170/90 mmHg over 2 days, despite a gradual increase in medication to verapamil 160 mg twice daily and prazosin 5 mg twice daily. Proteinuria 1/10th on boiling developed, and a 24-hour urinary protein was 0.21 g/litre. Clotting studies were normal. The patient was transferred to the labour ward for stabilisation and delivery.

A right internal jugular triple lumen central venous catheter, right radial intra-arterial cannula and CMV5

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ECG allowed continuous haemodynamic monitoring. The transduced blood pressure was 220/120 mmHg and central venous pressure (CVP) +12 mmHg. Peripheral parenteral infusions of magnesium sulphate 2 g/hour after a 4-g loading dose and glyceryl trinitrate 0.5 μg/kg/minute were established for anticonvulsant therapy and blood pressure control respectively. An unfavourable cervix was found on pelvic examination and a Foley catheter was inserted into the cervical canal and traction applied to promote ripening overnight.

Contractions began 6 hours later and an epidural catheter was inserted for pain control and attenuation of stress. During administration of three 2-ml aliquots of 0.25% bupivacaine over 20 minutes, the arterial pressure decreased to 127/70 mmHg and the patient reported nausea. Her CVP remained at +7 mmHg. The arterial pressure was restored to 180/95 mmHg with postural changes and polygeline 200 ml and CVP increased to +13 mmHg. On further epidural top up, titration of 0.25% bupivacaine 2 ml epidurally and 50 ml aliquots of polygeline intravenously every 15 minutes, were required to provide analgesia and maintain peripheral perfusion. Oliguria and difficult cardiovascular control required insertion of a thermodilution balloon-tipped, flow-directed pulmonary arterial catheter after 7 hours of her labour. Measurements were recorded in the left lateral position between contractions. A high systemic vascular resistance of 1632 dynes/sec/cm^5, low pulmonary vascular resistance, depressed cardiac output of 5.9 litres/minute and pulmonary artery wedge pressure of 15 mmHg was found (Fig. 1). Afterload reduction was instituted by a hydralazine infusion at 5 mg/hour and resulted in a 40% reduction of systemic vascular resistance and an improvement of cardiac output by 54%. To further improve cardiovascular stability pain relief was converted to an epidural infusion of 0.1% bupivacaine and fentanyl 1 μg/ml in 0.9% saline run at 4 ml/hour.

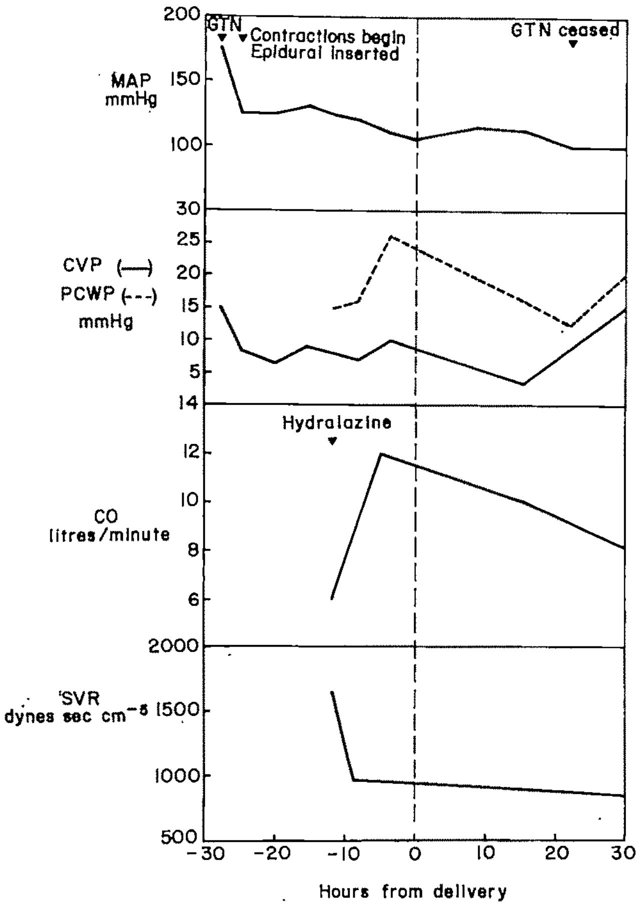

Fig. 1. Mean arterial pressure (MAP); central venous pressure (CVP); pulmonary capillary wedge pressure (PCWP), cardiac output in litres/minute (CO litres/minute); and systemic vascular resistance (SVR) dyne/cm sec^{-5} are plotted against time measured in hours before and after delivery. Arrows indicate management changes. Glyceryl trinitrate (GTN) and hydralazine were given as intravenous infusions.

Eleven hours after the onset of contractions syntocinon augmentation was established because of poor progress. Mild fetal distress intervened 6 hours later and coupled with cardiovascular instability and no further cervical dilatation, Caesarean section and tubal ligation were undertaken under lumbar epidural anaesthesia, the height of the block to pinprick being T_6 bilaterally. Anaesthesia was established with 1.5% mepivacaine 12 ml given incrementally over 30 minutes. Polygeline was titrated to maintain a wedge pressure of 15 mmHg and a stable arterial blood pressure. A 31-week live 1402 g male, with 1- and 5-minute Apgar scores of four and seven was delivered. His neonatal course was complicated by hyaline membrane disease, which required 4 days of artificial ventilation, and later by jaundice and apnoea of prematurity. Invasive monitoring of the mother was continued for 36 hours postoperatively. Analgesia was maintained by epidural infusion as above. Arterial blood pressure control required infusion of hydralazine for 36 hours and glyceryl trinitrate for 24 hours. Magnesium sulphate was reduced to 1 g/hour at 14 hours postdelivery and ceased at 36 hours.

Daily ECGs and cardiac enzymes were performed for 5 days after the operation. No changes were observed. No alteration in renal function was found and arterial blood pressure returned to pre-pregnant levels of 130/80 mmHg on continued medication. The patient was discharged on day 10. Postnatal review at 6 weeks found her asymptomatic but hypertensive at 160/100 mmHg with a further review to be conducted by her physician.

Discussion

Incidence and prognosis

The incidence of heart disease during pregnancy ranges from 0.4 to 4.1%,[6,7] with ischaemic heart disease a rare occurrence, in approximately 0.01% of pregnancies.[8] Acute myocardial infarction occurring during pregnancy was documented as 76 cases from 1922–1979 by Cortis[9] and since then a further 12 documented cases have been added.[10–18] Fletcher[19] estimated the incidence of this complication at 7.5/100 000 deliveries. However, pregnancy following myocardial infarction has been stated at only 13 cases in the world literature to 1978 by Radio and Chefetz[1] and including this report, a further seven cases have occurred.[2–5] Pre-eclampsia has complicated management on only two occasions of these 20 cases.[4–20]

Ginz,[8] in a review of 39 cases of acute myocardial infarction during pregnancy, stated overall mortality at 28%. Mortality increased from nil in the first trimester, 21% in the second, 40% in the third trimester and 50% in the puerperium. Those under 35 years had a 50% mortality outcome whereas over 35 years only a 10.5% mortality outcome. Hankins[13] found similar results in a review of 68 cases, but added a 75% mortality rate for recurrent infarction in the third trimester. Hughes[21] noted that 38% of women had diastolic pressures greater than 100 mmHg and that this worsened prognosis.

Pregnancy following myocardial infarction has not been associated with mortality but has with morbidity. Congestive cardiac failure occurred in four out of 20 cases, increased angina in four of 20 cases and cardiovascular instability in five out of seven documented cases.[1-5]

Management

Consideration of the management of pregnancy after myocardial infarction suffers from a paucity of previously reported clinical experience and must rely on an assessment of the reserve ability of a diseased myocardium to meet the physiological stresses of pregnancy, labour and possible surgery. Counselling in this case was undertaken with regard to termination. Radio and Chefetz[1] suggested detailed assessment of myocardial function but concluded that if time was allowed for myocardial healing, a return to normal function would be achieved and little or no maternal or fetal mortality would be associated. However, the pregnancy-associated morbidity of this and previously indicated cases would question this conclusion. Rhen,[20] in contrast, believes all patients with known coronary artery disease should be advised against pregnancy. Gast[4] suggests pregnancy continuation should be based upon careful patient selection which involves initial stress tests and echocardiography and follow up stress testing in the second and third trimester. It is evident that since numbers in the world literature are small, assessment of probable outcome can only be made on an individual basis with estimation of current ventricular function and degree of vessel impairment. A multidisciplinary approach with stress testing, echocardiography or catheter studies is required and was used in this case.

Admission in our case was prompted by the onset of pre-eclampsia superimposed upon essential hypertension. The diagnosis was based on the presence of an elevation in diastolic pressure greater than 15 mmHg and oedema. Proteinuria whilst present did not meet criteria for severe pre-eclampsia.[22,23] This is a complication which requires aggressive therapy. There is a progressive 45% increase in cardiac output in uncomplicated pregnancy,[2] mainly because of chronotropism, but also increased contractility and preload. This results in greater myocardial work and decreased time for coronary perfusion.[6] The elevation in afterload with pre-eclampsia is an additional burden. Parenteral glyceryl trinitrate was selected to provide a decrease in myocardial oxygen demand and improve coronary perfusion. This has been used on one occasion previously for acute myocardial infarction during pregnancy without fetal effects.[13]

Epidural analgesia was selected early for relief of pain, reduction in the Valsalva manoeuvre and attenuation of the gradual increase in preload stress and maternal catecholamine levels with labour progression.[2,15] This has been advocated by many authors.[2,5,6,14,24,25] Gradual titration of 0.25% bupivacaine was associated with one episode of nausea and hypotension (greater than 30% reduction in mean arterial pressure), but was treated by changes in posture. It is important to maintain diastolic pressure for coronary perfusion and although vasopressors were not needed in this instance, phenylephrine has been recommended as the appropriate agent despite the fact that it causes reduced uterine blood flow.[15] The predominantly beta sympathomimetic effect of ephedrine increases myocardial work, and metaraminol suggested by Abboud *et al.*[2] is a potent coronary vasoconstrictor. The increased sensitivity to catecholamines found in pre-eclamptics was also a potential hazard.[23] In order to avoid this problem, a 0.1% bupivacaine-combined narcotic epidural infusion was instituted before Caesarean section; local anaesthetic was slowly titrated against pulmonary artery wedge pressure.

The lateral position was employed during labour to minimise aortocaval compression and improve uterine blood flow. It has been postulated that reduced uterine blood flow in the supine position causes release of uterine renin and the subsequent elevation of angiotensin results in coronary artery spasm.[26] This has been suggested as a possible aetiology for third trimester acute myocardial infarctions in women with normal coronary angiography.[15,26] Spasm is a potential cause of re-infarction and the prophylactic use of parenteral glyceryl trinitrate and possibly the lateral position during labour may give protection.

Monitoring

Oliguria and worsening hypertension prompted insertion of a pulmonary artery catheter to guide further management. The measurement of the wedge pressure had the added benefit of providing an early indication of decreased left ventricular compliance induced by ischaemia. The poor correlation between CVP and wedge pressure was considered due to previous ischaemic damage; however, pre-eclampsia may also have been a cause.[27-29] Recent reports indicate up to 30% of pre-eclamptics may have poor correlation between CVP and wedge pressure and suggest that in the presence of oliguria or pulmonary oedema, routine use of a pulmonary artery catheter provides optimum information for management.[27,28] Clark *et al.*[29] reported similarly that in 14 of 15 obstetric patients with associated cardiac disease that there was poor correlation between CVP and wedge pressure. Invasive haemodynamic monitoring is becoming increasingly used in obstetrics and the combination of pre-eclampsia and cardiac dysfunction is an added indication.[2,3,29]

Delivery

The mode of delivery is an unresolved question and no clear trend emerges from the literature. It is often cited that Caesarean section should be undertaken only for obstetric indications and that vaginal delivery avoids the stress of surgery.[2,15,19,30,31] Roberts and Low[16] suggest elective Caesarean section if there is cardiac decompensation and Ginz,[8] concluded that management of the actual delivery was based more on belief than knowledge. Of 16 pregnancies following acute myocardial infarction that reached 31 weeks, delivery was effected by Caesarean section in five cases (three elective) and vaginally in 11 cases (seven assisted). There was no mortality in either group. Maternal morbidity and neonatal outcome cannot be effectively compared, as cases stretch from 1943 to 1987 and vary in detail. However, the incidence of myocardial re-infarction after anaesthesia in noncardiac surgery is quoted at 4% with a 53% mortality rate when the previous infarct is over 24 months old.[32,33]

Caesarean section was undertaken in this case for fetal distress. Epidural anaesthesia was chosen to avoid the hypertension and tachycardia associated with tracheal intubation common in pre-eclampsia and detrimental in ischaemic heart disease.[34] However this technique has its opponents. Abboud *et al.*[2] suggest that if Caesarean section needs to be performed, light general anaesthesia with a slow fentanyl induction is preferable to regional anaesthesia. This would necessarily lead to compromise to secure the airway early, but the need to attenuate the cardiac stress of the tracheal intubation with fentanyl is avoided when regional anaesthesia is used.[35] The maintenance of uteroplacental blood flow with an epidural technique was also considered important for a distressed fetus.[36] The benefit of extended postoperative invasive haemodynamic monitoring and early intervention has been shown to reduce re-infarction in noncardiac surgery from 7.7% to 1.9%.[37] However monitoring for the recommended 96 hours postoperatively was logistically difficult in our institution.

Prostaglandin E_2 is a coronary vasodilator and would theoretically be the agent of choice for labour augmentation. However, it is unavailable in Australia so dilute syntocinon was used. Harkins *et al.*[13] postulated that the transient pressor responses and coronary vasoconstriction reported with high dose oxytocin were not observed with their two cases, probably because of its dilute form. However, dilution should be coupled with judicious use under continuous ECG and pulmonary artery monitoring.

Ischaemic heart disease in pregnancy can be managed successfully provided careful patient selection, multidisciplinary antenatal care, and optimisation of myocardial oxygen supply and demand is achieved. Full haemodynamic monitoring is necessary for intrapartum and immediate post partum management to allow early intervention.

References

1. Radio GJ, Chafetz MD. Successful pregnancy following myocardial infarction: a case report. *International Journal of Gynaecology and Obstetrics* 1978; **16:** 228–32.
2. Abboud TK, Williams V, Henriksen EH. Anaesthetic management of the parturiant with a recent myocardial infarction. *Anesthesiology Review* 1980; **7:** 17–9.
3. Diro M, Beydoun SN, Jaramillo B, O'Sullivan MJ, Kieval J. Successful pregnancy in a woman with a left ventricular cardiac aneurysm. A case report. *Journal of Reproductive Medicine* 1983; **28:** 559–63.
4. Gast MJ, Rigg LA. Class H diabetes and pregnancy. *Obstetrics and Gynacology* 1985; **66:** 5s–7s.
5. Chestnut DH, Zlatnik FJ, Pittun RM, Varner MW. Pregnancy in a patient with a history of myocardial infarction and coronary artery bypass grafting. *American Journal of Obstetrics and Gynecology* 1986; **155:** 372–3.
6. Sullivan JM, Ramanathan KB. Management of medical problems in pregnancy: severe cardiac disease. *New England Journal of Medicine* 1985; **313:** 304–9.
7. Sugrue D, Blake S, Macdonald D. Pregnancy complicated by maternal heart disease at the National Maternity Hospital, Dublin, Ireland, 1969–1978. *American Journal of Obstetrics and Gynaecology*; 1981 **139:** 1–6.
8. Ginz B. Myocardial infarction in pregnancy. *Journal of Obstetrics and Gynaecology of the British Commonwealth* 1970; **77:** 610–15.
9. Cortis BS, Freese E, Luisada AA, Motto S, Zummo B, Hal G. Precordial pain and myocardial infarction in pregnancy. *Giornale Italiano di Cardiologia* 1979; **9:** 532–4.
10. Iffy L, Tenhove W, Frisoli G. Acute myocardial infarction in the puerperium in patients receiving Bromocriptine. *American Journal of Obstetrics and Gynecology* 1986; **154:** 371–3.
11. Hutchison SJ, Holden RJ, Lorimer AR. Myocardial infarction in pregnancy. *Scottish Medical Journal* 1985; **30:** 116–8.
12. Taylor GJ, Cohen B. Ergonovine-induced coronary artery spasm and myocardial infarction after normal delivery. *Obstetrics and Gynaecology* 1985; **66:** 821–2.
13. Harkins GDV, Wendel GD Jr, Leveno KJ, Stoneham J. Myocardial infarction during pregnancy: a review. *Obstetrics and Gynecology* 1985; **65:** 139–46.
14. Stokes IM, Evans J, Stone M. Myocardial infarction and cardiac arrest in the second trimester followed by assisted vaginal delivery under epidural analgesia at 38 weeks gestation: case report. *British Journal of Obstetrics and Gynaecology* 1984; **91:** 197–8.
15. Cohen WR, Steinman T, Patsner B, Snyder D, Satwicz P, Monroy P. Acute myocardial infarction in a pregnant woman at term. *Journal of the American Medical Association* 1983; **250:** 2179–81.
16. Roberts ADG, Low RAL, Rae AP, Hills WS. Left ventricular aneurysm complicating acute myocardial infarction occurring during pregnancy: case report. *British Journal of Obstetrics and Gynaecology* 1983; **90:** 969–70.
17. Majdan JF, Walinsky P, Cowchock SF, Wapner RJ, Plzak L Jr. Coronary artery bypass surgery during pregnancy. *American Journal of Cardiology* 1983; **52:** 1145–6.
18. Chant GN. Coronary anatomy in postpartum acute myocardial infarction. *American Journal of Cardiology* 1980; **45:** 912.
19. Fletcher E, Knox EW, Morton P. Acute myocardial infarction in pregnancy. *British Medical Journal* 1967; **3:** 586–2.
20. Rhen K, Salokannel H. Pregnancy and delivery after myocardial infarction. *Annals Chirurgiae et Gynaecologiae Fenniae* 1967; **56:** 385–8.
21. Hughes TBJ, Charters DW. Myocardial infarction in pregnancy. *New Zealand Medical Journal* 1975; **81:** 445–56.
22. Writer WDP. Anaesthetic considerations in high risk pregnancy. *Canadian Anaesthetists' Society Journal* 1986; **33:** s16–s27.
23. Wright JP. Anesthetic considerations in pre-eclampsia-eclampsia. *Anesthesia and Analgesia* 1983; **63:** 590–601.
24. Chestnut DJ, Roberts SL, Laube DW, Martins JB. Pregnancy in a patient with aneurysms of the right coronary artery and an aterioventricular fistula. A case report. *Journal of Reproductive Medicine* 1986; **31:** 528–30.
25. Schnider SM, Abboud TK, Atral R, Henricksen EH, Stefani SJ, Levinson G. Maternal catecholamines decrease during labor after lumbar epidural anesthesia. *American Journal of Obstetrics and Gynecology* 1983; **147:** 13–5.
26. Sasse L, Wagner R, Murray FE. Transmural myocardial infarction during pregnancy. *American Journal of Cardiology* 1975; **35:** 448–52.
27. Phelan JP, Yurth DA. Severe pre-eclampsia. I Peripartum hemodynamic observations. *American Journal of Obstetrics and Gynecology* 1982; **144:** 17–22.
28. Benedetti TJ, Kates R, Williams V. Hemodynamic observations in severe pre-eclampsia complicated by pulmonary edema. *American Journal of Obstetrics and Gynecology* 1985; **152:** 330–4.
29. Clark SL, Horenstein JM, Phelan JP, Montag TW, Paul RH. Experience with the pulmonary artery catheter in obstetrics and gynecology. *American Journal of Obstetrics and Gynecology* 1985; **152:** 374–8.
30. Hughes TBJ. Myocardial infarction and rheumatic heart disease in pregnancy: case report. *British Journal of Obstetrics and Gynaecology* 1975; **82:** 505–7.
31. Mendelson CL. Coronary artery disease in pregnancy. *American Journal of Obstetrics and Gynecology* 1952; **63:** 381–91.
32. Tarhan S, Moffitt EA. Taylor WF, Giuliani ER. Myocardial infarction after general anesthesia. *Journal of the American Medical Association* 1972; **220:** 1451–4.
33. Steen PA, Tinker JH, Tarhan S. Myocardial reinfarction

after anesthesia and surgery. *Journal of the American Medical Association* 1978; **239**: 2566–70.

34. Hodgkinson R, Husain FJ, Hayashi RH. Systemic and pulmonary blood pressure during caesarean section in parturients with gestational hypertension. *Canadian Anaesthetists' Society Journal* 1980; **27**: 389–94.
35. Newsome LR, Bramwell RS, Curling PE. Severe pre-eclampsia: hemodynamic effects of lumbar epidural anesthesia. *Anesthesia and Analgesia* 1986; **65**: 31–6.
36. Jouppila R, Jouppila P, Hollmen A, Koivula A. Lumbar epidural analgesia to improve intervillous blood flow during labor in severe pre-eclampsia. *Obstetrics and Gynecology* 1982; **59**: 158–61.
37. Rao TLK, Jacobs KH, El-Etr AA. Reinfarction following anesthesia in patients with myocardial infarction. *Anesthesiology* 1983; **59**: 499–505.

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CASE HISTORY

Spinal subdural haematoma following spinal anaesthesia

G. L. BARKER

Summary

A case is presented of spinal subdural haematoma which developed after spinal anaesthesia.

Key words

Anaesthetic technique, regional; spinal.
Complications; haematoma.

Spinal anaesthesia, in the absence of contraindications, is an acceptable technique for total hip replacement. Subdural haematoma formation after a subarachnoid block is an extremely rare complication; such a case is presented here.

Case history

An 87-year-old female was admitted for a total hip replacement after long standing osteoarthritis. Past medical history included an 8-year history of asthma and a mild hemiparesis after a cerebrovascular accident 5 years previously. She was receiving prednisolone and used a salbutamol inhaler.

Temazepam 10 mg and metoclopramide 10 mg were given orally one hour pre-operatively. A 22-gauge needle was introduced into the subarachnoid space at the L_{2-3} interspace with the patient in the right lateral position. The procedure was atraumatic and heavy 0.5% bupivacaine 2 ml were used to provide anaesthesia. The patient was sedated with incremental fentanyl (total dose 100 μg) and midazolam (total dose 5 mg). Hydrocortisone 100 mg was also given. Fluid replacement consisted of Hartmann's solution 500 ml and Dextran 70 in saline 500 ml. Pulse rate and arterial blood pressure remained normal throughout the procedure and blood loss was recorded as unremarkable.

She was noted to be sleepy on the first postoperative day, but otherwise appeared well. Approximately 48 hours after operation the patient's condition deteriorated; she became more sleepy, uncooperative, and developed atrial fibrillation for which she received digitalis.

She was noted to be paraplegic with no cord function below D_{12} on her fourth postoperative day. There was a gradual deterioration in her general condition over the next few days, and she died on the tenth day after operation.

Examination of the spinal cord at postmortem revealed a subdural haematoma which extended from D_{10} down to the filum terminale (Fig. 1). The spinal cord in this region was described as swollen, mottled and soft.

Discussion

It is well established that central nervous system sequelae after subarachnoid anaesthesia are uncommon.[1,2] There are reports of epidural haematoma formation after epidural or spinal anaesthesia in patients who receive anticoagulant therapy, and as a result these forms of anaesthesia are considered contraindicated in the presence of clotting abnormalities.[3]

Spinal subdural haematoma formation is in contrast exceedingly rare. There are only 12 cases reported in the English literature according to a recent review,[4] and of these six were subdural, and six were both subarachnoid and subdural. In only one of these cases did the insertion of the needle involve the administration of an anaesthetic. The majority (79%) of haematomata occurred in patients with a coagulopathy, significant thrombocytopenia, or who had received anticoagulants.

The source of the spinal subdural bleeding is not clear. There is an anastomosing network of subdural vessels in which the major vessels are directed longitudinally along the lateral margin of the posterior surface of the dura. The only vessels more than 1 mm in diameter are the major radiculomedullary vessels of Adamkiewicz within the subarachnoid space below L_2. They usually enter the spinal cord above the L_3 nerve root, but can occasionally accompany the L_4 or L_5 nerve root.[5,6] There are no bridging subdural vessels similar to those seen over the cerebral hemispheres. As a result of this anatomy, a lumbar puncture performed in the midline below L_3 is unlikely to

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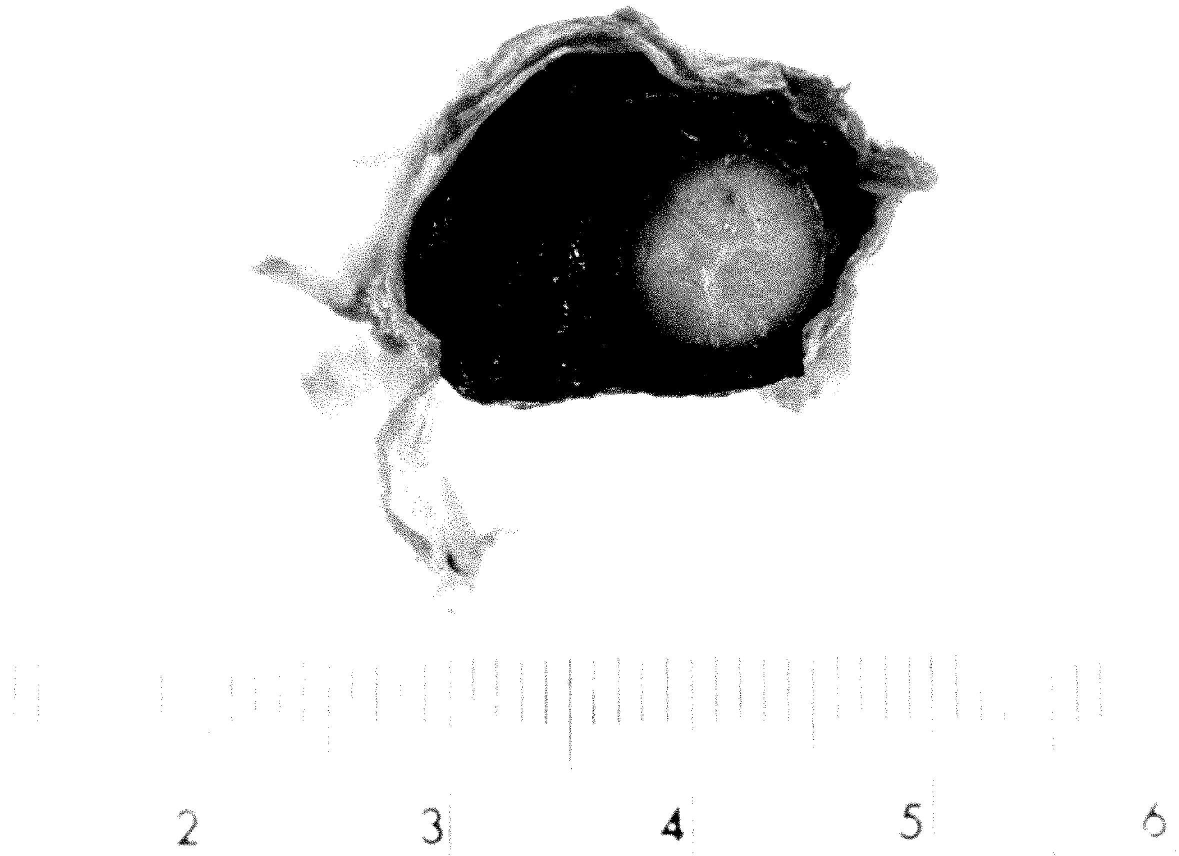

Fig. 1. A section of spinal cord at D_{11} which shows extensive subdural haematoma formation.

involve subarachnoid or subdural vessels large enough to cause significant bleeding. No anticoagulants were prescribed and there was no record of asprin intake in the 7 days before surgery, although aspirin is not routinely restricted.

The cause of the subdural haematoma in this patient is unknown. Such an occurrence is very rare, and although it must be considered as a potential complication, it should not detract from the well documented advantages of this form of anaesthesia.[7,8]

References

1. Dripps RD, Vandam LD. Hazards of lumbar puncture. *Journal of the American Medical Association* 1951; **147:** 1118–21.
2. Phillips OC, Ebner H, Nelson AT, Black MH. Neurologic complications following spinal anesthesia with lidocaine: a prospective review of 10,440 cases. *Anesthesiology* 1969; **30:** 284–9.
3. DeAngelis J. Hazards of subdural and epidural anesthesia during anticoagulant therapy: A case report and review. *Anesthesia and Analgesia* 1972; **51:** 676–9.
4. Owens EL, Kasten GW, Hessel EA. Spinal subarachnoid hematoma after lumbar puncture and heparinization: A case report, review of the literature, and discussion of anesthetic implications. *Anesthesia and Analgesia* 1986; **65:** 1201–7.
5. Suh TH, Alexander L. Vascular system of the human spinal cord. *Archives of Neurology and Psychiatry* 1939; **41:** 659–77.
6. Gillilan LA. Veins of the spinal cord, anatomic details; suggested clinical applications. *Neurology* 1970; **20:** 860–8.
7. Scott DB, Thorburn JT. Spinal anaesthesia. *British Journal of Anaesthesia* 1975; **47:** 421–2.
8. Bryce-Smith R. The enigmas of spinal analgesia. *Proceedings of the Royal Society of Medicine* 1976; **69:** 75–82.

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CASE REPORT

Multiple anaesthetics for a malignant hyperthermia susceptible patient

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Summary

A patient is described who has received nine anaesthetics, the last three since he was confirmed as susceptible to malignant hyperthermia. The ninth anaesthetic illustrates the prophylactic therapy and management in detail. Certain aspects of the problem are discussed.

Key words

Complications; malignant hyperthermia.

Malignant hyperthermia (MH) is now a familiar entity. Instances during and after anaesthesia have been recorded since 1900,[1–4] but not until 1960[5,6] was it recognised as a distinct syndrome with a familial pattern. The pathophysiology, genetic characteristics, incidence, drugs likely to trigger a reaction, laboratory investigations which confirm the susceptibility of a person to this syndrome, and management and treatment are well documented,[7,8] although further elucidation and investigation of certain aspects of the problem are required.

The first suspicion that a patient suffers from this condition usually occurs during anaesthesia. The symptoms vary from facial muscle (masseter) spasm after the administration of suxamethonium, and/or mild hyperthermia, to a fulminating attack. This report describes an MH susceptible (MHS) patient who received nine anaesthetics up until the time of writing (the ninth, of 9.5 hours duration) from different anaesthetists. The last three were administered by the author after the condition was diagnosed; all were uneventful, apart from an abnormal reaction to suxamethonium during the fourth anaesthetic.

Case history

The 18-year-old, patient, one of nonidentical Caucasian male twins, was born with a congenital cleft lip and palate. He is normal in all other respects, has no known allergies and does not suffer from any chronic illness. He has received nine anaesthetics, mainly to enable surgical repair and adjustment of the congenital defects. Six anaesthetics were given for five operations between 4 months and 12 years, (Table 1). He had three uneventful anaesthetics before the age of seven, when he was scheduled to have a pharyngoplasty performed. Anaesthesia was induced in the manner described in Table 1, (anaesthetic four) after oral premedication with atropine 0.027 mg/kg and trimeprazine tartrate syrup 1.9 mg/kg. However, to facilitate oral tracheal intubation, suxamethonium 1.19 mg/kg was given intramuscularly to the patient who weighed 22 kg. Some generalised muscle fasciculation occurred but breathing continued until his lungs were inflated several times. Tracheal intubation was attempted, but his jaw was rigidly closed with his teeth clenched. Lung inflation with 100% oxygen was carried out, during which he gradually relaxed; the procedure was abandoned. His serum creatinine phosphokinase, following this episode, was found to be 830 I.U. (normal range 0–90) 4 days after the operation. No explanation for this, or for the reaction to suxamethonium, was noted at the time. Two weeks later he was again anaesthetised in the same manner (anaesthetic 5) but without suxamethonium. Tracheal intubation caused no problem under 'deep' halothane, nitrous oxide and oxygen anaesthesia, and a pharyngoplasty was performed in 1.25 hours. He had a further operation under general anaesthetic (six) uneventfully at 12.5 years of age, without suxamethonium. Two years later, however, after inspection of the anaesthetic records MHS was suspected. He was referred for muscle biopsy,* where the neuropharmacological muscle contracture tests with halothane and caffeine proved positive, after electromyography which proved negative.

Information about the last three anaesthetics is shown in Table 2. The overall conduct of general anaesthesia has changed considerably and extensive noninvasive monitoring was carried out. Intravenous dantrolene, other resuscitative drugs, ice readily to hand, and a volatile agent-

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Table 1. Regimens followed for the patient's six anaesthetics up to 12 years of age.

Anaesthetics	1	2	3	4	5	6
Age	4 months	2 years	6 years	7 years	7 years	12.5 years
Weight	5.5 kg	10 kg	not known	21.8 kg	21.8 kg	34.5 kg
Operation	cleft lip repair	palate repair	tonsil-lectomy	pharyngoplasty	pharyngoplasty	sulcoplasty
Premedication 2 hours before operation						intramuscular:
oral atropine	0.4 mg	0.6 mg	not known	0.6 mg	0.6 mg	atropine 0.6 mg
oral trimeprazine				42 mg	42 mg	papaveretum 10 mg 1 hour before operation
Induction	N_2O,O_2 halothane oral tube	N_2O,O_2 halothane oral tube	not known	N_2O,O_2 halothane intramuscular suxamethonium 50 mg	N_2O,O_2 halothane oral tube	thiopentone 250 mg N_2O,O_2 halothane oral tube
Maintenance	N_2O,O_2 halothane	N_2O,O_2 halothane	not known	mask O_2	N_2O,O_2 halothane	N_2O,O_2 halothane
Ventilation	spontaneous	spontaneous	not known	assisted	spontaneous	spontaneous
Ayre's system, modified T-piece[9,10]	yes	yes	not known	yes	yes	adult nonreturn
Duration	1.5 hours	1.5 hours	not known	—	1.25 hours	1 hour
Intravenous infusion	no	no	not known	yes	yes	no
Blood loss	not known	60 ml, approximately	not known	not known	not known	not known

free anaesthetic machine, were standard protocol for these procedures. The body of increasing evidence which concerns the prophylactic use of oral dantrolene influenced its use in the pre-operative 24 hours,[11–13] in anaesthetics eight and nine. Neostigmine was given in small increments at intervals, without previous atropinisation, at the completion of operation eight (the pulse-rate was carefully monitored) and no problem was encountered.

The last procedure was performed at the end of 1986. Induction of anaesthesia was carried out in the following manner in order to avoid injury to the pharyngoplasty flap and consequent performance of a tracheostomy. The airway was secured with an orotracheal tube after induction of anaesthesia; this was then changed to a nasotracheal tube passed over a fibreoptic laryngoscope, inserted in the right nostril and carefully negotiated past the pharyngoplasty. A nasogastric tube was inserted to allow feeding to start 2 or 3 days after the operation. Battery-operated calf-muscle stimulators were attached, and an aluminium foil 'blanket' was used in the early part of the operation. A measured blood loss of 2 litres was replaced with 1 litre of blood (unreconstituted packed cells), 1 litre of plasma, and 3 litres of crystalloid, in a peripheral vein. Central venous pressure was measured with a right antecubital-placed catheter. Urine output was measured from an indwelling urinary catheter. Other drugs given during the procedure included antibiotics (cephradine and metronidazole), and methylprednisolone to reduce postoperative oedema. The anaesthetic was uneventful: the rectal temperature increased slowly during the first 3 hours from 35.5°C to 36.2°C, the foil blanket was removed, and the water mattress (which was maintained at 35°C) turned off. The temperature continued to increase slowly to a maximum of 36.7°C and then began to decrease and by the end of the procedure it was 36.3°C. Emergence from anaesthesia was uneventful: he wakened very quickly, and within an hour the tracheal tube was withdrawn from the larynx, shortened, and left as a nasopharyngeal airway (his teeth had not been wired together). His rectal temperature rose to 37.9°C 2 hours after the operation and remained at this level for about one hour; it decreased to 37.2°C during the fourth postoperative hour, and then to 37°C.

Discussion

Malignant hyperthermia is a disorder which occurs under certain specific conditions, particularly when a susceptible patient is exposed to most of the volatile anaesthetic agents, depolarising muscle relaxants, and certain other groups of drugs.[7,8] There are many published reports of the successful treatment of an acute manifestation of this syndrome, and perhaps many unpublished successfully managed incidences (previous personal patient experience). It can be concluded that anaesthetists prevent the occurrence of the syndrome because the mortality rate of 70% 18 years ago[7] had decreased to 50% 8 years ago,[7] and to less than 10% 2 years ago.[8] One of the main reasons must be anaesthetists' general awareness of the condition and the drugs likely to cause a reaction. However, there are probably other unidentified reasons for this reduction in mortality. Drugs known to induce MH include all volatile anaesthetic agents, and suxamethonium. An excess of endogenous noradrenaline may be the immediate trigger of stress-induced reactions.[8] Parasympatholytics and sympathomimetics worsen established reactions, and the latter have been incriminated in those reactions caused by large volumes of amide linkage local anaesthetic drugs.[8] These local anaesthetic agents are now known to be quite safe, while atropine and drugs that elevate myoplasmic calcium (cardiac glycosides and calcium salts) will aggravate a crisis,

Table 2. Regimens followed for the patient's last three anaesthetics.

Anaesthetic	7	8	9
Age	15.5 years	16 years	17 years
Weight	56 kg	61 kg	63 kg
Operation	teeth extractions	lip revision and of palatal fistula	bilateral maxillary osteotomy and bone graft
Premedication	oral diazepam 10 mg 2 hours before operation	oral diazepam 12 mg 2 hours before operation	intramuscular papaveretum 10 mg 1 hour before operation
Induction	thiopentone 300 mg N_2O,O_2 pancuronium 5 mg oral tube	thiopentone 325 mg N_2O,O_2 vercuronium 5 mg oral tube	thiopentone 350 mg N_2O,O_2 pancuronium 6 mg oral tube
Volatile agent	no	no	no
Maintenance breathing system	nonreturn	nonreturn	circle with CO_2 absorber
Ventilation, IPPV	Manley Vt 650 ml × 14	Manley Vt 600 ml × 12	Manley Servovent Vt 650 ml × 14
Maintenance	N_2O,O_2	N_2O,O_2	N_2O,O_2
Relaxant	nil	vercuronium 1 mg × 2	pancuronium 2 mg × 6
Analgesic drugs	papaveretum 5 mg × 3	fentanyl 0.05 mg × 1 0.025 mg × 2	papaveretum 5 mg × 8 fentanyl 0.05 mg × 5
Volatile agent	no	no	no
Antibiotics	nil	nil	cephradine 500 mg × 2 metronidazole 500 mg × 2
Methylprednisolone	nil	nil	250 mg × 1 125 mg × 2
Drugs at termination of anaesthesia	droperidol 2.5 mg	neostigmine 0.5 mg × 4	droperidol 2.5 mg × 2
Duration of surgery	1.75 hours	1.75 hours	9.5 hours
Intravenous infusion	500 ml dextrose 4% in saline 0.18%	500 ml dextrose 4% in saline 0.18%	4750 ml blood, plasma, saline
Monitoring			
ECG (continuous)	yes	yes	yes
Arterial pressure (non-invasive)	yes	yes	yes
End tidal CO_2	yes	yes	yes
Inspiratory O_2	yes	yes	yes
Rectal temperature	yes	yes	yes
Oximetry	no	no	yes
CVP	no	no	no
Water mattress	yes, off	yes, off	yes: on, later off

but not actually cause one (Ellis: personal communication). It can probably be assumed that glycopyrronium has a similar effect to atropine. Psychoactive drugs such as mono-amine oxidase inhibitors, phenothiazines (trimeprazine), butyrophenones, tricyclics, and amphetamines can cause an idiosyncratic response, termed the neurolept malignant syndrome (NMS); and for the present these should be avoided.[8]

This patient received nine anaesthetics, eight of which were uneventful. He was exposed to some of the MH-inducing agents during the first six, seemingly without any problem except for anaesthetic number four. Suxamethonium was given at that time which caused masseter spasm. This history is not uncommon, especially in children (Ellis: personal communication) and raises the question, why is a major problem delayed until several anaesthetics later? Does the syndrome mature with increasing age? There are no answers yet and identified patients must be treated according to current knowledge. This patient has received 'safe' anaesthetic techniques since anaesthetic number six. However, hyperpyrexic episodes have occurred up to 6 hours postoperatively after the administration of 'safe' anaesthetics,[14] which required active treatment, while the cause remained unknown. The three reported case histories showed the presence of postoperative stress, probably because of insufficient pain relief. Mild hypothermia occurred during anaesthesia, and shivering and hypertension followed in the postoperative period. The one patient who did not have a muscle biopsy had had a hemithyroidectomy for a euthyroid nodule, so an endocrinopathy may yet have been present to play a part in his reaction. A drug was used in the premedication in all the cases, and another in the induction of anaesthesia, which are not readily identifiable. The patients were all treated with dantrolene; the serum creatinine phosphokinase elevation that follows is usually attenuated or absent in MH patients. However, in all these instances, this enzyme level was elevated . Thus, it is possible that one, and perhaps others, in this report may not have been true MH reactions: they could have been NMS manifestations or a reaction by a normal member (MHN) of a malignant hyperpyrexia family. Even so, monitoring of patients must be conducted for at least the first 12 hours of the postoperative phase. It was decided to give prophylactic oral dantrolene (5 mg/kg) during the preoperative 24 hours in order to try to prevent a reaction in the reported case. The efficacy of this had been shown in animals,[15] and is recommended by Wingard,[11] and Britt.[8] Failure of prophylactic oral dantrolene to prevent MH in man has been reported;[16,17] this may have been because of inadequate dosage and/or poor absorption from this route of administration. However, in both cases, electromyography (EMG) was omitted, as were the caffeine and halothane contracture tests in one.[16] A decrease in pulmonary compliance with the appearance of copious pulmonary secretions occurred in the other case,[17] and could have been a symptom of some other myopathy, although the patient's previous muscle biopsy was positive. Neither patient became pyrexial and both were readily aborted, which suggested that the reactions were modified, probably because of the pre-operative dantrolene medication. Intravenous administration (5 mg/kg), before induction of anaesthesia, has been recommended,[18] but this is not the practice of authorities in the UK, as it is thought that the known and unknown risks outweigh the benefits. A compromise was made in this case, with regard to the various recommendations but it is not known whether this helped the patient.

Is the patient really malignant hyperthermia susceptible? It has been reported that masseter spasm has a prevalence of nearly 1% in children anaesthetised with halothane and suxamethonium,[19] approximately 50% of whom were diagnosed as MHS.[20] Why is it, then, that so few episodes of MH occur? Are the diagnostic tests unreliable? Unvalidated tests have been listed[21] and the diagnosis thus rests on the validity of the halothane and caffeine contracture tests. It has been stated that 'the critical question whether a positive halothane or caffeine contracture test reliably identifies patients as MHS, remains unanswered'.[21] The validity of these tests relies on a 50:50 breakdown of MHS to MHN (normal) when patients who have a 0.5 probability for MH are investigated (assuming single gene dominant inheritance). However, when the results of the European MH Group and the controls, especially, are inspected, a complete separation between controls and MH reactors is demonstrated (Ellis: personal communication).

A study of a group of probands[22] revealed that of 100 who showed spasm when given suxamethonium during the course of an anaesthetic, 64 were MHS and the remainder were not susceptible (according to muscle biopsy tests). No diagnosis was made for 27 of this latter group, approximately half of whom (12 of the total), were rigorously screened and had normal EMGs. This group is worth further evaluation[22] because it is possible that they have inherited part of the syndrome,[23] which may later progress to MHS. They must be followed up and require careful drug and anaesthesia administration when the occasion arises.

Few episodes of malignant hyperthermia occur, however, in spite of many who are susceptible being exposed to risk. A study some years ago showed the probability of MH developing to be 44%.[7] More recent information may confirm this probability to be much less. It could be argued, using this patient's data, that the probability of his developing an episode during a future anaesthetic is 10%. The reason why so few episodes occur remains puzzling and may be related to as yet unidentified stress factors.[24] It should be noted that during the last procedure on the patient in this report, blood loss of 2 litres occurred. Usually, a relative hypotensive technique is used when indicated, but was not in this case, because this patient's reaction to such drugs (sodium nitroprusside) was unknown.

In conclusion, no easy, cheap method of screening patients presently exists but a particular test on lymphocytes seems to show promise.[25] Present biochemical estimations (serum CK) are not confirmatory diagnostic tests;[26] the only available and reliable ones are currently pharmacological and histological, performed upon muscle biopsies—clearly an impossible task to be undertaken routinely. Thus, when it is suspected a patient has this syndrome, electromyography (EMG) and serum creatinine phosphokinase are the first investigations to be carried out. A normal EMG excludes muscle dystrophy disorders and elevated enzyme levels indicate that further investigations are necessary, but patients with normal levels will also require further investigation.

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References

1. Gibson CL. Heat-stroke as post-operative complication. *Journal of the American Medical Association* 1900; **35:** 1685.
2. Moschcowitz AV. Post-operative heatstroke. *Surgery, Gynecology and Obstetrics* 1916; **23:** 443–51.
3. Burford GE. Hyperthermia following anesthesia. A consideration of control of body temperature during anesthesia. *Anesthesiology* 1940; **1:** 208–15.
4. Brown RC. Hyperpyrexia and anaesthesia. *British Medical Journal* 1954; **2:** 1526–7.
5. Denborough MA, Lovell RRH. Anaesthetic deaths in a family. *Lancet* 1960; **II:** 45.
6. Denborough MA, Forster JFA, Lovell RRH, Mapleston PA, Villiers JD. Anaesthetic deaths in a family. *British Journal of Anaesthesia* 1962; **34:** 395–6.
7. Ellis FR, Halsall PJ: Malignant hyperyrexia. *British Journal of Hospital Medicine* 1980; **24:** 318–27.
8. Britt BA. Malignant hyperthermia. *Canadian Anaesthetists' Society Journal* 1985; **32:** 666–77.
9. Ayre TP. Endotracheal anesthesia for babies: with special reference to hare-lip and cleft palate operations. *Current Researches in Anesthesia and Analgesia* 1937; **16:** 330–3.
10. Rees GJ. Anaesthesia in the newborn. *British Medical Journal* 1950; **2:** 1419–22.
11. Wingard DW. Controversies regarding the prophylactic use of dantrolene for malignant hyperthermia. *Anesthesiology* 1983; **58:** 489–90.
12. Britt BA. Dantrolene. *Canadian Anaesthetists' Society Journal* 1984; **31:** 61–75.
13. British National Formulary (BNF). *British Medical Association and The Pharmaceutical Society of Great Britain,* 1987; **13:** 414.

14. GRINBERG R, EDELIST G, GORDON A. Postoperative malignant hyperthermia episodes in patients who received 'safe' anaesthetics. *Canadian Anaesthetists' Society Journal* 1983; **30:** 273–6.
15. KERR DD, WINGARD DW, GATZ EE. Prevention of porcine malignant hyperthermia by oral dantrolene. In: ALDRETE JA, BRITT BA, eds. *Second International Symposium on Malignant Hyperthermia.* New York: Grune and Stratton, 1978; 499–507.
16. FITZGIBBONS DC. Malignant hyperthermia following preoperative oral administration of dantrolene. *Anesthesiology* 1981; **54:** 73–5.
17. RUHLAND G, HINKLE AJ. Malignant hyperthermia after oral and intravenous pretreatment with dantrolene in a patient susceptible to malignant hyperthermia. *Anesthesiology* 1984; **60:** 159–60.
18. FLEWELLEN EH III. Malignant hyperthermia and associated conditions: dilemma, controversy, unanswered questions. *Proceedings of the International Anesthesia Research Society, Review Course Lectures.* 1985: 76–82.
19. SCHWARTZ L, ROCKOFF MA, KOKA BV. Masseter spasm with anesthesia: incidence and implications. *Anesthesiology* 1984; **61:** 772–5.
20. ROSENBERG H, FLETCHER JE. Masseter muscle rigidity and malignant hyperthermia susceptibility. *Anesthesia and Analgesia* 1986; **65:** 161–4.
21. MULDOON SM. Malignant hyperthermia update. *American Society of Anesthesiologists' Annual Refresher Course* 1986: Lecture 151: 1–3.
22. ELLIS FR, HALSALL PJ. Suxamethonium spasm. A differential diagnostic conundrum. *British Journal of Anaesthesia* 1984; **56:** 381–84.
23. WINGARD DW. Malignant hyperthermia—acute stress syndrome in man. In: HENSCHEL EO, ed. *Malignant hyperthermia: current concepts.* New York: Appleton-Century-Crofts. 1977: 79–95.
24. WINGARD DW. Malignant hyperthermia: a human stress syndrome? *Lancet* 1974; **2:** 1450–1.
25. BRITT BA. Malignant hyperthermia. *Canadian Anaesthetist's Society Journal* 1985; **32:** 672.
26. ELLIS FR, CLARKE IMC, MODGILL M, CURRIE S, HARRIMAN DFG. Evaluation of creatinine phosphokinase in screening patients for malignant hyperpyrexia. *British Medical Journal* 1975; **3:** 511–3.

Anaesthesia, 1988, Volume 43, pages 671–674

CASE REPORT

Subarachnoid spread of epidural local anaesthetic following dural puncture

A. LEACH AND G. B. SMITH

Summary

A case is described of an extensive block and hypotension which occurred after inadvertent dural puncture and subsequent epidural injection of bupivacaine. The subarachnoid spread of solution from the extradural space was confirmed radiologically.

Key words

Anaesthetic techniques, regional; epidural.
Complications; hypotension.

Dural puncture is a well recognised complication of lumbar epidural analgesia, as is extensive block after extradural injection of local anaesthetic solutions in patients in whom the dura has been punctured. However, the mechanism of spread of local anaesthetic has been the subject of much speculation. We report a case of extensive block after dural puncture with radiological evidence of spread from the extradural to the subarachnoid space.

Case history

A healthy 33-year-old primiparous Caucasian woman whose height was 1.62 m and who weighed 78 kg presented at term with her membranes ruptured after an uneventful pregnancy, at which time her arterial blood pressure was 120/80 mmHg. An intravenous infusion was established and a fetal scalp electrode attached. At the L_{1-2} interspace the dura was inadvertently punctured with a Tuohy needle (saline was used to identify the space) at a depth of 4.5 cm. There was a free flow of cerebrospinal fluid (CSF) which showed a glucose level of 4.5–6.5 mmol/litre using a 'B-Mstix'. A further attempt was made to locate the space at the same interspace. Loss of resistance was encountered at 4 cm but resulted in a steady drip of fluid from the needle, which was again shown to be CSF.

Attempts to locate the epidural space at L_{2-3} also failed, but it was eventually identified at T_{12}–L_1 at a depth of 3.5 cm and a catheter successfully passed a distance of 3 cm into the space. No CSF or blood could be aspirated from the catheter. A test dose of 0.5% plain bupivacaine 3 ml gave no evidence of spinal block and a further 5 ml was injected through the catheter with the mother lying on her left side; 5 minutes later she was turned onto her right side. Her arterial pressure at this stage was 110/80 mmHg, pulse rate 90 beats/minute and fetal heart rate 140/minute.

Twenty-five minutes after injection of the test dose there was a sudden decrease in arterial pressure to 80/50 mmHg. She started to shiver violently and there was a further decrease to 70/40 mmHg. Administration of 500 ml of Hartmanns solution and one litre of polygeline resulted in increase of arterial pressure to 80/40 mmHg. Intravenous ephedrine was then given in increments of 3 mg to a total of 12 mg which restored the arterial pressure to 95/60 mmHg. The fetal heart rate varied between 125 and 145/minute during this hypotensive episode and there was no significant change in the maternal pulse rate. Sensory loss to pinprick extended to the T_2 dermatome at this time. The mother remained conscious and alert during this whole period and no respiratory depression was observed.

Three hours after initial insertion of the epidural catheter a further top-up was indicated. However, aspiration through the epidural catheter resulted in free withdrawal of CSF. Another catheter was sited, with difficulty, at the L_{2-3} interspace, since she still expressed a desire for epidural analgesia; loss of resistance occurred at 5 cm from the skin. Plain bupivacaine 3 ml of 0.5% was injected and another 3 ml 15 minutes later. This produced a sensory block to T_{11} on the left side and L_1 on the right. A further increment of 0.25% bupivacaine 4 ml was therefore injected with the patient lying in the right lateral position. Forty-five minutes after the initial test dose a sensory block to the level of T_4 was demonstrated. A transient decrease in arterial pressure to 90/50 mmHg was noted during this period. Further top-ups were given 3 and 5 hours later with small divided doses of 0.5% bupivacaine. The final top-up again

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produced a sensory block to T_3; however, her arterial blood pressure remained stable at 100/70 mmHg.

A Caesarean section was performed later that day under general anaesthesia for failure to progress in labour, and a male infant who weighed 3.6 kg. was delivered in good condition. Apgar scores were 9 at one minute and 10 at 5 minutes. The mother was nursed flat with an epidural infusion of 1 litre of N saline given over the next 24 hours after recovery from anaesthesia. The next day she complained of no uncomfortable sequelae and with her informed consent 3 ml of Omnipaque 180 water-soluble contrast medium was injected through the epidural catheter. This demonstrated extradural spread of contrast between T_{11} and L_3 and a small leak of contrast into the subarachnoid space at the level of L_{1-2} (Figs 1 and 2). Tilting the patient feet down caused the contrast within the subarachnoid space to trickle down to the level of L_3. The patient subsequently developed a typical spinal headache which required an autologous blood patch. A week after discharge from hospital she complained only of an intermittent mild headache and stiffness of the lower lumbar region.

Discussion

Extensive spread of local anaesthetic during epidural analgesia may be because of a number of well established causes, such as subarachnoid or subdural injection. The former is characterised by the rapid onset of hypotension, profound motor and sensory blockade, loss of consciousness and apnoea and it requires prompt and skilled resuscitation. The latter has been well documented and confirmed radiologically.[1,2] The characteristics of subdural injection were suggested by Collier in 1982,[3] namely a slow onset of symptoms over 15–20 minutes, moderate hypotension and progressive respiratory depression rather than

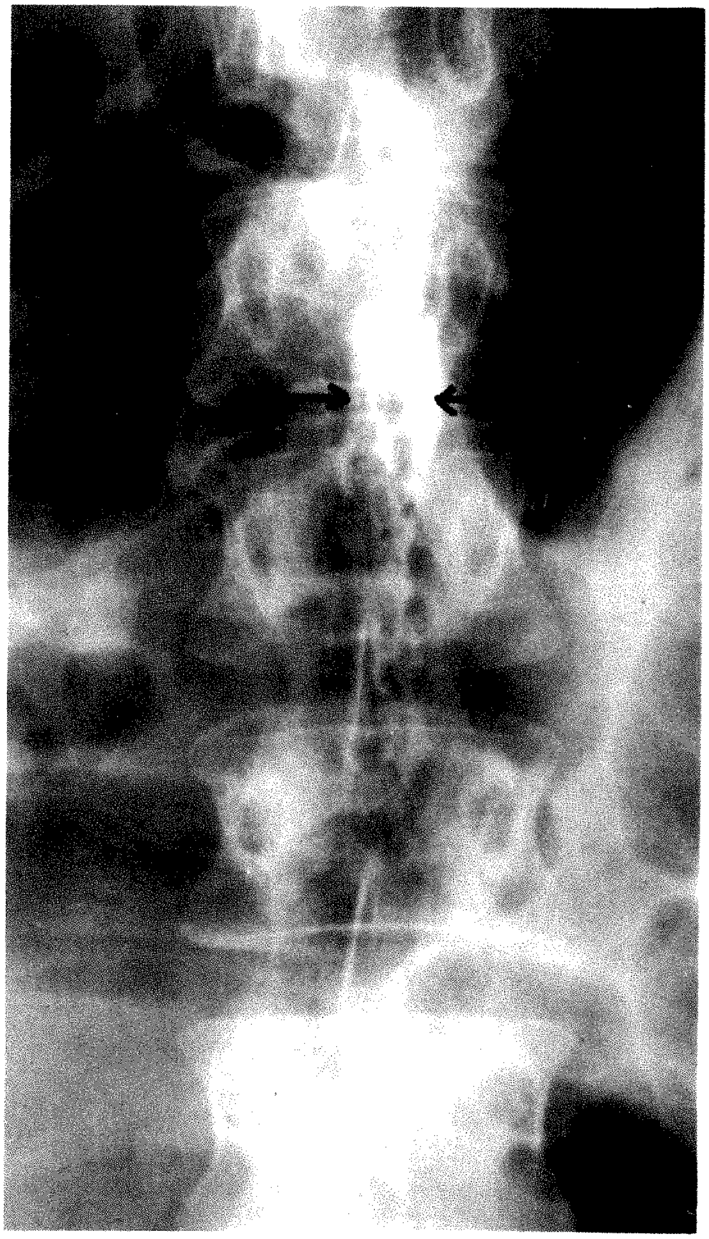

Fig. 1. Anteroposterior view of lumbar spine which shows X ray contrast (arrowed) within the subarachnoid space.

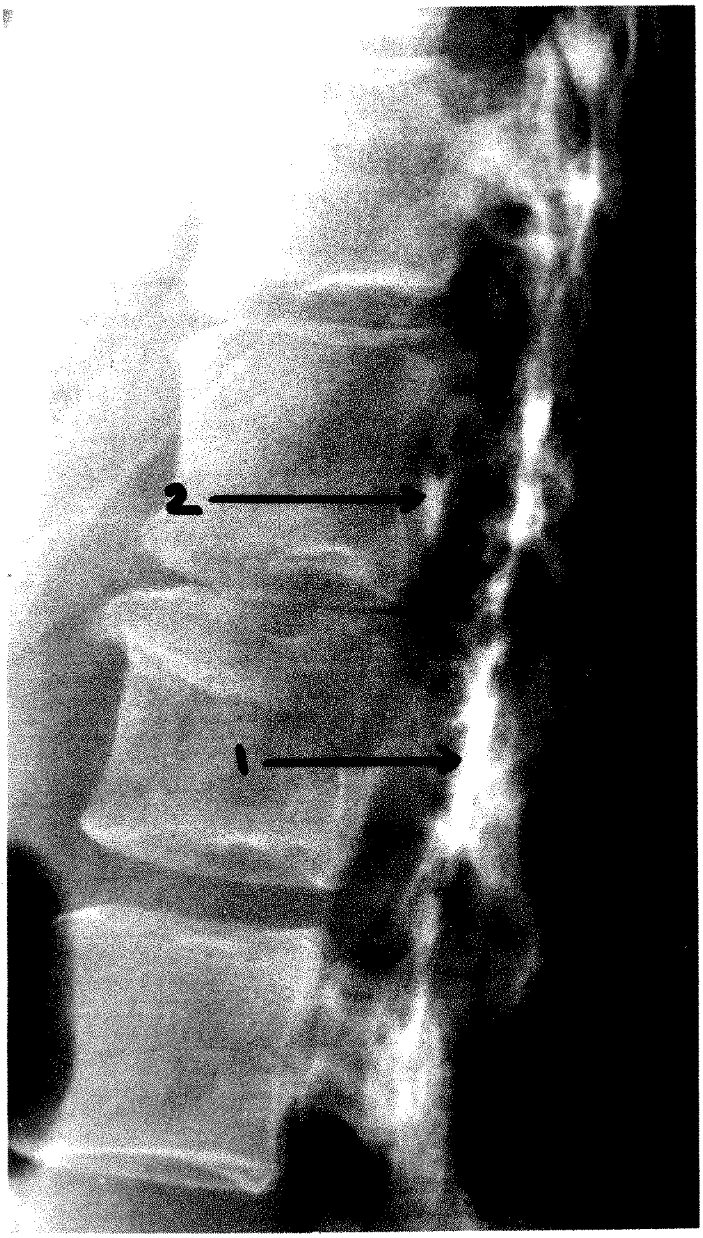

Fig. 2. Lateral view of lumbar spine which shows X ray contrast lying extradurally (arrowed 1) and in the subarachnoid space (arrowed 2).

apnoea. Recovery is usually more rapid than after subarachnoid injection.

It has also been suggested by Sykes[4] and Hodgkinson[5] that extensive spread may follow injection of local anaesthetic at an interspace adjacent to a dural puncture site. In Hodgkinson's cases,[5] large volumes of 0.75% bupivacaine were injected at an interspace cephalad to a dural puncture site before Caesarean section. The patients were having regular and frequent uterine contractions in the cases in which extensive spread occurred and the development of hypotension and extensive sensory blockade took place over a period of 8–40 minutes. All cases required tracheal intubation and ventilation. The duration from onset of sensory block to complete recovery was 250–390 minutes and therefore compatible with subarachnoid spread.

In our case much smaller volumes of local anaesthetic were used to produce analgesia in labour. Regular, frequent uterine contractions were experienced, the onset of extensive block was longer than anticipated with direct subarachnoid injection (45 minutes), hypotension was observed, but the upper limit of sensory spread was T_2 and there was no respiratory depression. Duration of analgesia was 180 minutes. The mechanisms that underly this phenomenon have been suggested previously,[4] where it was postulated that analgesic solution might slowly leak into the CSF through the dural puncture hole. Mesry[6] suggested that the extensive spread happened as a result of leakage of large volumes of CSF into the epidural space thereby diluting the local anaesthetic solution and causing extensive and uncontrolled spread. In none of the previous reports has there been radiological confirmation of the mechanism of spread of solution.

The radiological findings in our case confirm the suspicions of others[4,5] that the spread may occur through the dural puncture site. The radiological appearances of injection of contrast into the subarachnoid, subdural and epidural spaces have been discussed elsewhere.[2,7] Our findings show that injection through the catheter was predominantly into the epidural space which indicates that the catheter had not migrated through the hole in the dura. Spread was also seen to occur from the epidural space into the subarachnoid space (arrowed, Figs 1 and 2) and the contrast within the subarachnoid space characteristically was seen to be affected by posture. The abnormal spread that resulted with the first catheter at T_{12}–L_1 may also have been because of a similar mechanism, although this was not confirmed radiologically.

That such transarachnoid spread can occur at first seems unlikely because of the pressure gradient which causes CSF to leak outward into the epidural space.[8,9] However, studies have shown that epidural compliance does vary with age and also that individual variations do occur. In patients with low compliance, epidural pressure during injection, especially when large volumes of solution are used and during regular uterine contractions, may briefly exceed CSF pressure and allow such transarachnoid flow to occur.

This case report, as did Hodgkinson's,[5] questions the management of dural puncture in labour. It demonstrates that abnormally extensive spread may take place after injection of the smaller volumes of local anaesthetic required for analgesia in labour. We certainly agree with Hodgkinson[5] that much smaller doses of local anaesthetic than normal should be used if dural puncture is caused during epidural anaesthesia for Caesarean section. This may be a preferable alternative in such cases while more experience is gained with spinal anaesthesia for Caesarean section. We recommend that a more cephalad interspace be used in all cases, when dural puncture occurs during epidural analgesia for labour, and meticulous observation of the mother and fetus should be carried out after each top-up.

References

1. Boys JE, Norman PF. Accidental subdural analgesia: a case report, possible clinical implications and relevance to 'massive extradurals'. *British Journal of Anaesthesia* 1975; **47:** 1111–3.
2. Brindle Smith G, Barton FL, Watt JH. Extensive spread of local anaesthetic solution following subdural insertion of an epidural catheter during labour. *Anaesthesia* 1984; **39:** 355–8.
3. Collier C. Total spinal or massive subdural block? *Anaesthesia and Intensive Care* 1982; **10:** 92.
4. Sykes MK. Delayed spinal analgesia. A complication of epidural analgesia. *Anaesthesia* 1958; **13:** 78–83.
5. Hodgkinson R. Total spinal block after epidural injection into an interspace adjacent to an inadvertent dural perforation. *Anesthesiology* 1981; **55:** 593–5.
6. Mesry S. Massive epidural spread of local analgesics. *Anaesthesia* 1976; 31: 576–7.
7. Mehta M, Maher R. Injection into the extra-arachnoid subdural space. Experience in the treatment of intractable cervical pain and in the conduct of extradural (epidural) analgesia. *Anaesthesia* 1977; **32:** 760–6.
8. Moir DD. *Obstetric anaesthesia and analgesia.* London: Baillere-Tindall, 1976: 29–30.
9. Usubiaga JE, Wikinski JA, Usubiaga LE. Epidural pressure and its relation to spread of anaesthetic solutions in epidural space. *Anesthesia and Analgesia* 1967; **46:** 440–6.

Anaesthesia, 1988, Volume 43, pages 675–676

CASE REPORT

Hyponatraemia and mental symptoms following vesical ultrasonic lithotripsy

Y. K. BATRA, R. KAPOOR, A. K. HEMAL AND S. VAIDYANATHAN

Summary

A patient became confused and restless after vesical ultrasonic lithotripsy performed with distilled water as the irrigant. Serum sodium decreased to 120 mmol/litre from the pre-operative value of 138 mmol/litre. A cystogram revealed intraperitoneal extravasation of contrast. She recovered promptly after intravenous infusion of normal saline and emergency surgery for repair of the damaged bladder wall. This case illustrates that hyponatraemia and mental symptoms similar to those following transurethral resection syndrome also occur with ultrasonic lithotripsy when distilled water is used as the irrigant.

Key words

Surgery; ultrasonic lithotripsy.
Complications.

Hyponatraemia, restlessness, and confusion because of absorption of irrigating fluid have been described after transurethral resection of prostate. We describe a similar complication after vesical ultrasonic lithotripsy performed with distilled water as the irrigant.

Case history

A 45-year-old female patient presented with suprapubic pain and strangury. Systemic examination was normal. Haemoglobin, blood urea, and blood sugar were within normal limits. Urine culture was sterile. X ray revealed a vesical calculus of 3 cm in diameter. Intravenous urography revealed normal upper urinary tracts; urinary bladder was of good capacity and its contour smooth. She was not receiving any medication. Her pre-operative arterial blood pressure was 130/70 mmHg and pulse rate 76 beats/minute. Premedication consisted of morphine 7.5 mg and promethazine 25 mg intramuscularly one hour before surgery.

Vesical ultrasonic lithotripsy was performed under epidural analgesia with a Karl Storz Lutzeyer Lithotripter, with distilled water as the irrigant. The procedure had taken 100 minutes when she became restless and confused. About 40 litres of irrigant had been used and she had received 0.3 litre of normal saline intravenously during this period. Her arterial blood pressure had increased to 170/90 mmHg with a pulse rate of 64 beats/minute. Her abdomen was soft and there was no distension.

Hyponatraemia, caused by absorption of the irrigation fluid, was suspected and a blood sample was taken for estimation of electrolytes before further saline infusion administration. A Foley catheter introduced per urethram was draining clear urine. Her mental symptoms disappeared completely over a course of 3 hours after the intravenous administration of 300 ml of 3% saline. A cystogram performed subsequently revealed intraperitoneal extravasation of contrast (Fig. 1). Surgery performed after 6 hours, revealed no obvious perforation in the bladder. About one litre of fluid was found in the peritoneal cavity. An area that measured 1.0 × 1.5 cm in the base of the bladder above the trigone which was bluish, oedematous, and friable was excised; the resulting hole in the bladder was repaired in two layers and a suprapubic cystotomy performed. The suprapubic tube was removed after 10 days, and at one month follow-up she was asymptomatic. The results of haematological and biochemical investigations are given in Table 1.

Discussion

Hyponatraemia and central nervous symptoms such as restlessness, confusion, coma, and seizures have been described after transurethral resection of prostate. The neurological sequelae are ascribed to the sudden decrease in serum sodium with its attendant fluid shifts and acute cerebral oedema. This case exemplifies that a similar

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Table 1. Results of haematological and biochemical investigations.

	Haemoglobin (gm%)	Haematocrit (%)	Serum Na⁺	Serum K⁺ (mmol/litre)	Serum Cl⁻	Mental symptoms
Before operation	13.5	45	138	4.1	102	Nil
At the end of ultrasonic lithotripsy	12.5	40	120	3.5	90	Restlessness Confusion
1 hour later	12.0	42	124	3.3	90	Restlessness Confusion
3 hours later	12.0	42	134	3.8	96	Nil
24 hours after ultrasonic lithotripsy	13.0	45	140	4.2	101	Nil

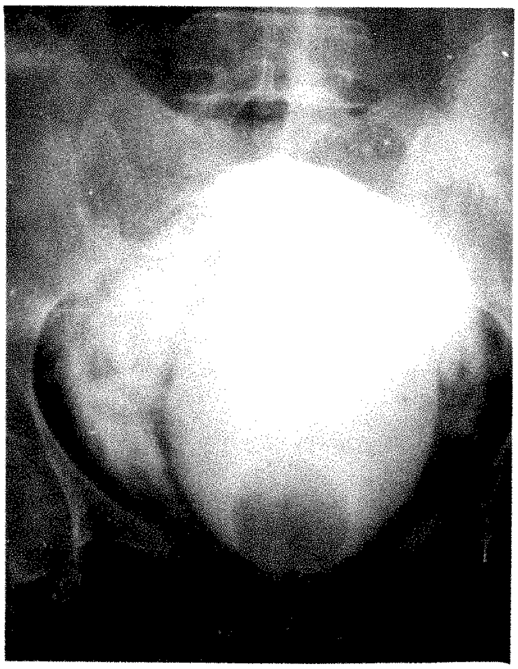

Fig. 1. Cystogram performed after visical ultrasonic lithotripsy shows intraperitoneal extravasation of contrast.

complication can also occur after vesical ultrasonic lithotripsy. The amount of fluid absorbed, during transurethral resection of the prostate, is directly related to the resection time. In the case of ultrasonic lithotripsy, irrigation fluid can be absorbed if the mucosa is damaged, and the extent of absorption will be related to the duration of bladder irrigation required for lithotripsy. Metabolic derangements occur when hyponatraemia exists because of bladder perforation, as reported by Weber and his associates,[1] with a time course significantly different from that usually seen in the transurethral resection of prostate syndrome. In their case, initial measurement of serum sodium showed only a minimal decrease but subsequently it decreased continuously over a period of 6 hours. A tense abdomen was also a prominent feature. The absence of abdominal distension and onset of hyponatraemia and mental symptoms immediately after ultrasonic lithotripsy in the present case suggest absorption of irrigation fluid through the damaged mucosa. The mental symptoms cleared promptly with the administration of hypertonic saline.

The time taken for ultrasonic lithotripsy should be limited to one hour in order to reduce the chances of excessive fluid absorption and resultant hyponatraemia. Vesical ultrasonic lithotripsy was carried out in this patient for 100 minutes in an overzealous attempt not to leave any residual stone fragment. It would have been prudent to stop the procedure after 60 minutes and perform lithotripsy of any remaining stone fragment at a later date. Further, distilled water was used as the irrigant in this case. Physiological saline may be used as the irrigant,[2] because ultrasonic stone disintegration involves no electric current, and will not cause hyponatraemia and its attendant fluid shifts. The dilutional effects, cost, and potential neurotoxicity of glycine contraindicate its use as irrigant for ultrasonic lithotripsy.

In conclusion, this case emphasises that hyponatraemia can occur after vesical ultrasonic lithotripsy and the anaesthetist should be ready to institute remedial measures.

References

1. Weber S, Acuff JH, Mazloomdoost M, Kirimli BI. Transurethral prostatectomy complicated by intraperitoneal extravasation of irrigating fluid. *Canadian Journal of Anaesthesia* 1987; **34:** 193–5.
2. Schultz RE, Hanno PM, Wein AG, Levin RM, Pollack HM, Van Arsdalen KN. Percutaneous ultrasonic lithotripsy: choice of irrigant. *Journal of Urology* 1983; **30:** 858–60.

Anaesthesia, 1988, Volume 43, pages 677–682

APPARATUS

Clinical trial of the Continucath intra-arterial oxygen monitor

A comparison with intermittent arterial blood gas analysis

P. M. PFEIFER, D. T. PEARSON AND R. H. CLAYTON

Summary

An intra-arterial continuous display oxygen electrode for radial artery cannulation is now available in the UK. Nine catheters were used in patients during and after hypothermic cardiac surgery. Results obtained were compared with those from conventional intermittent blood gas samples. Slow temperature response times negate its use during hypothermic surgery. A good correlation was found during the postoperative period. Indications for its use are discussed.

Key words

Equipment; arterial catheter, oxygen electrode.

The measurement of arterial oxygen tension ($Pa\text{o}_2$) is usually an intermittent process because a blood sample has to be taken and then injected into a blood gas analyser. An instrument which displays a continuous $Pa\text{o}_2$ reading has a number of advantages for both the patient and the medical staff. There is no risk of deterioration of the sample during transport to the laboratory, and the waiting time for the result is eliminated. Patient safety is increased as $Pa\text{o}_2$ is monitored continuously and any change is detected immediately. Upper and lower limit alarms can be set. Treatment of patients with respiratory failure may be facilitated by the ability to see variations and trends in $Pa\text{o}_2$ after adjustment of therapy more clearly than with intermittent arterial sampling. Continuous monitoring of $Pa\text{o}_2$ would be useful for specific anaesthetic problems, for example, the management of patients treated with bleomycin, in whom the $Pa\text{o}_2$ could be maintained below the range at which toxicity is likely.[1] Finally, continuous monitoring is an aid to the nursing staff. It abolishes the need to perform routine repetitive measurements, for example on the intensive therapy unit (ITU) following cardiac surgery.

The Continucath intra-arterial oxygen electrode manufactured by Biomedical Sensors Ltd (UK) has recently been promoted for routine clinical use. We have studied its performance during hypothermic cardiac surgery and also its reliability when used by nursing staff. We describe its use in a clinical setting and compare the results obtained with those from intermittent blood gas sampling with an IL 1302 blood gas analyser.

Methods

Figure 1 shows the Continucath monitor and sensor electrode. It is compact (205 mm × 120 mm × 140 mm), battery operated and thus portable. The $Pa\text{o}_2$ is measured electrochemically with a Clark type bipolar electrode in a thin flexible heparin-bonded polyethylene tube. The electrode diameter is 0.55 mm and passes through a 20-gauge catheter. The monitor box has an analogue meter display of $Pa\text{o}_2$, scaled in both kilopascals (kPa) and millimetres of mercury (mmHg). An isolated analogue output is also available. There are variable upper and lower alarm controls with auditory and visual signals and a mute button. Nitrous oxide and temperature compensation switches and a fine calibration dial are positioned on the front panel. Compensation for the presence of nitrous oxide is achieved by altering the electrode polarisation voltage from 800 mV to 600 mV.

Patients who presented for cardiac surgery were studied because radial artery cannulation is routine, mandatory, and continues for many hours into the postoperative period. The radial artery was cannulated under local analgesia with an 18- or 20-gauge B–D cannula before induction of anaesthesia and the intra-arterial electrode was attached, and advanced 15 cm into the artery. A continuous flushing device and a sampling port were also connected. The monitor was set during bypass surgery to compensate for the presence of nitrous oxide and in the postoperative phase in ITU it was set to measure $Pa\text{o}_2$ in the absence of nitrous oxide. The temperature compensation dial was set at 37°C throughout. The Continucath meter was calibrated initially by setting the calibration dial to a position defined by the manufacturer for each sensor electrode. This was then adjusted by measuring the oxygen tension in an arterial sample with the IL 1302 blood gas analyser (BG$P\text{o}_2$); the Continucath monitor was adjusted to read the same value on the dial (CATH$P\text{o}_2$). This calibration step, which must be performed during a period of $Pa\text{o}_2$ stability, was

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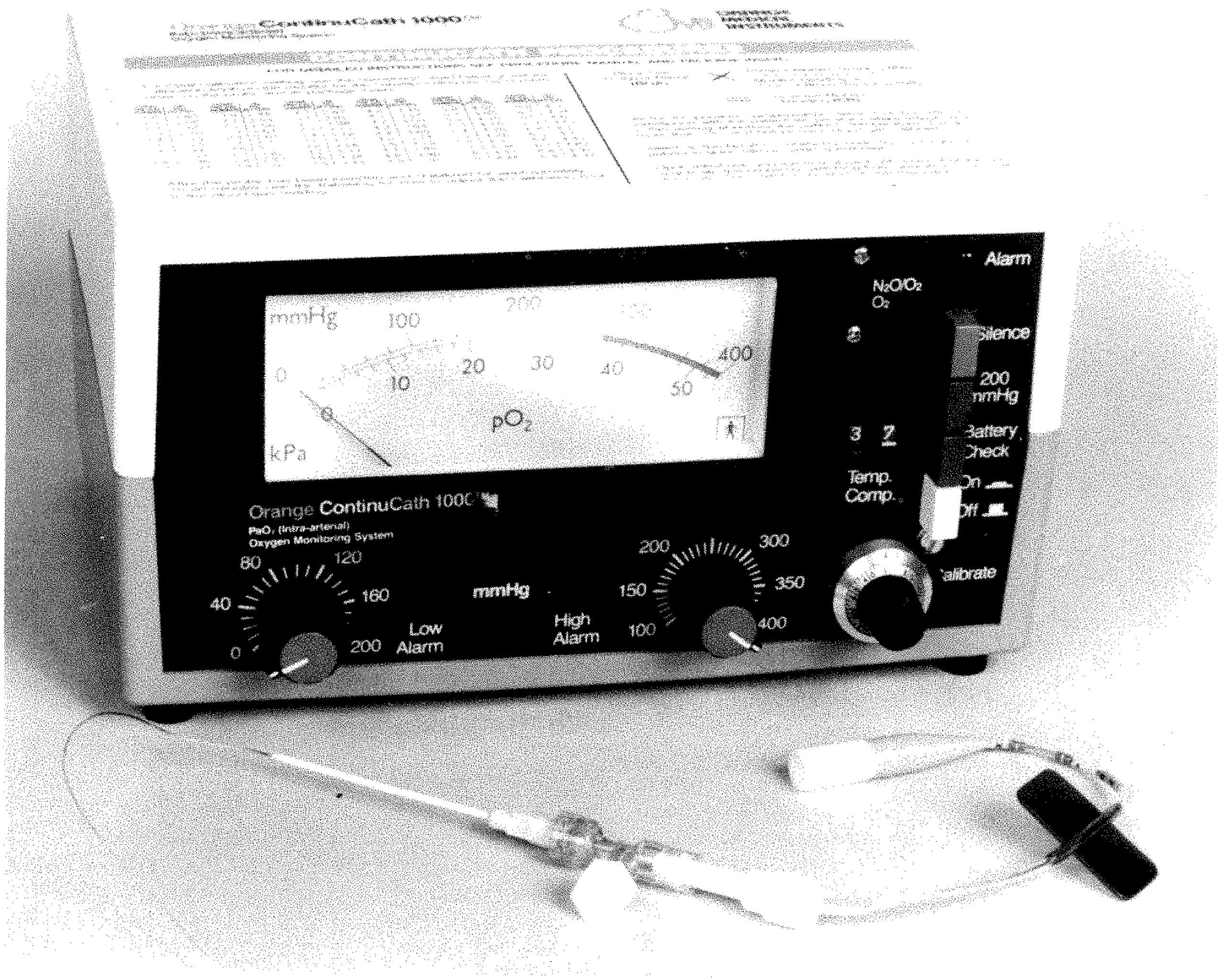

Fig. 1. The Continucath monitor and intra-arterial $Pa\text{O}_2$ electrode.

undertaken twice, once in theatre in the presence of nitrous oxide and once in ITU in the absence of nitrous oxide.

To assess the accuracy of the Continucath, intermittent arterial blood samples were taken and analysed for BG$P\text{O}_2$ and CATH$P\text{O}_2$ was recorded at the same time. The patient's core temperature was measured with an oesophageal probe. Readings were taken during the postoperative ventilatory period using a variety of inspired oxygen concentrations.

The IL 1302 blood gas analyser performs its measurement at 37°C. The temperature of the Continucath electrode varies during cardiac surgery with the patient's temperature. The electrode readings (CATH$P\text{O}_2$) were temperature-corrected to 37°C to allow comparison of the two analytical techniques. Repeated adjustment of the Continucath monitor temperature compensation dial was avoided by setting the dial to 37°C; each reading was then corrected for temperature. The manual gives a temperature calibration curve from which we derived the formula:

$$F = 3.891 - 0.125T + 0.00125T^2$$

where T is the temperature at which the measurement was taken and F is the factor by which the Continucath reading is multiplied to correct to 37°C.

An analogue output signal from the Continucath monitor was recorded on to magnetic tape to obtain the data to produce a continuous recording of arterial $Pa\text{O}_2$. The output from an oesophageal temperature probe was also recorded. These analogue signals were then sampled every 5 seconds by computer to allow production of the graphic output.

Results

Figure 2 demonstrates the continuous trace obtained of arterial $Pa\text{O}_2$ in a 59-year-old patient who underwent mitral valve replacement. The trace shows the arterial $Pa\text{O}_2$ changes during induction of anaesthesia, start and finish of cardiopulmonary bypass, and electrical defibrillation of the heart.

Figure 3 is a plot of temperature-corrected CATH$P\text{O}_2$ divided by BG$P\text{O}_2$ against time for patient 1. Complete agreement between the two methods would give a value of unity. The data for the first 3 hours were obtained in the operating theatre during the aortic valve replacement; the remainder represent 22 hours of monitoring on ITU postoperatively. The prominent peak in the first 2 hours is associated with induced hypothermia for surgery. This

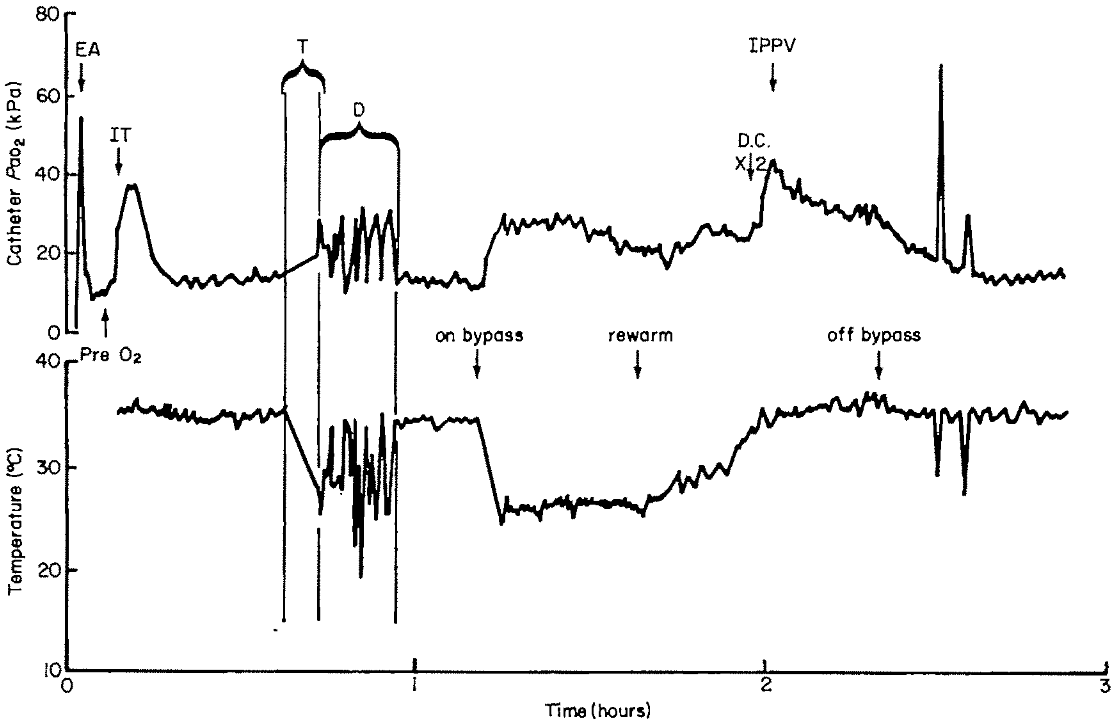

Fig. 2. A continuous record of intra-arterial Pa_{O_2} and oesophageal temperature during mitral valve replacement. EA, electrode activation; Pre O_2, pre-oxygenation; IT, intubation; T, transfer from anaesthetic room to theatre; D, interference from diathermy; D.C. × 2, cardiac defibrillation twice; IPPV, restart of mechanical ventilation.

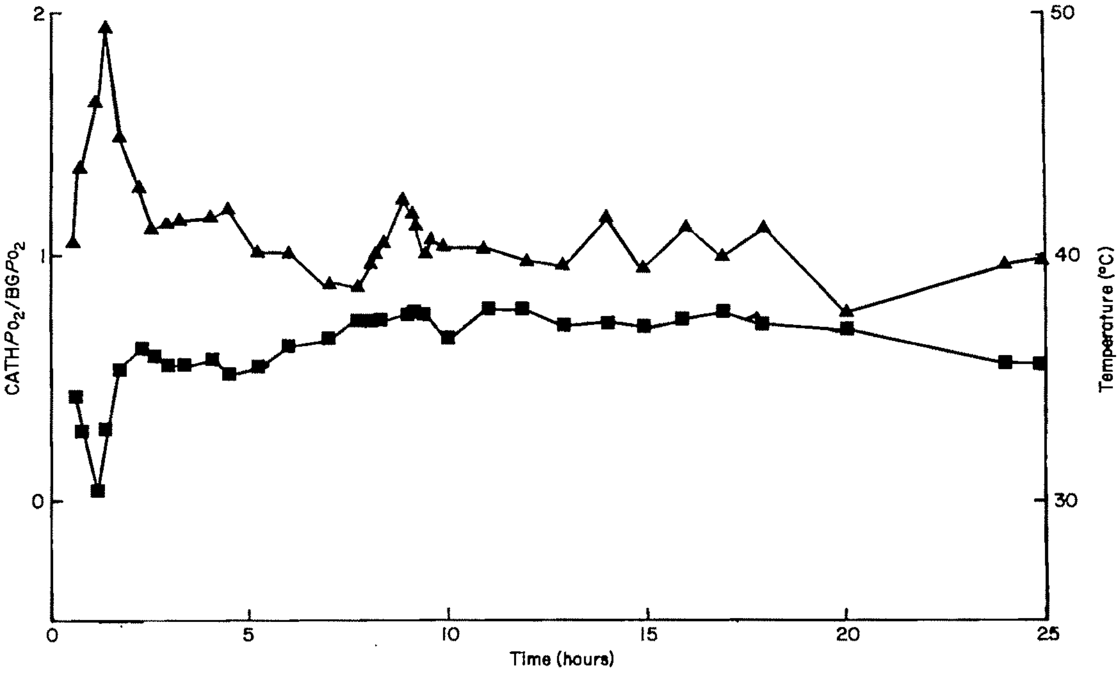

Fig. 3. The CATHP_{O_2}/BGP_{O_2} ratio (▲) and temperature (■) of patient 1.

deviation of CATHP_{O_2}/BGP_{O_2} ratio was variable and did not occur in every patient; this suggests that it was caused by something other than the temperature correction formula since this was the same for all patients. It may be a function of the response time of the Continucath to changing temperature. Consequently, only results recorded on ITU after recalibration of the monitor in the absence of nitrous oxide were analysed further.

The correlation coefficient derived from a plot of CATH-P_{O_2} against BGP_{O_2} was calculated for each of the nine catheters (Table 1). Patient 4 had a marked intrapulmonary shunt; the highest BGP_{O_2} was 21.8 kPa despite ventilation with an inspired oxygen fraction (F_{IO_2}) of 0.6. The Table also records the number of samples taken from each catheter and the number of hours that each was in place; it was not possible to aspirate blood from six of the nine catheters at the time of removal.

Figure 4 summarises the results of all nine catheters.

Table 1. Patients' age, sex and surgical procedure, the number of samples taken and hours in place for each catheter, patency before removal and individual correlation coefficients of CATHP_{O_2} against BGP_{O_2}.

Patients				Catheters			
Number	Age	Sex	Surgery	Hours	Samples	Patency	r
1	69	M	AVR	17	32	B	0.97
2	71	M	AVR	23	39	B	0.95
3	69	M	AVR	17	29	B	0.95
4	55	M	CABG	25	38	P	0.70
5	40	M	CABG	14	33	P	0.99
6	71	M	AVR	22	31	P	0.98
7	56	M	CABG	21	25	B	0.98
8	56	M	CABG	13	16	B	0.98
9	61	M	CABG	15	20	B	0.97

AVR, aortic valve replacement; CABG, coronary artery bypass graft; B indicates catheter was blocked before removal; P indicates a patent catheter; r, correlation coefficient.

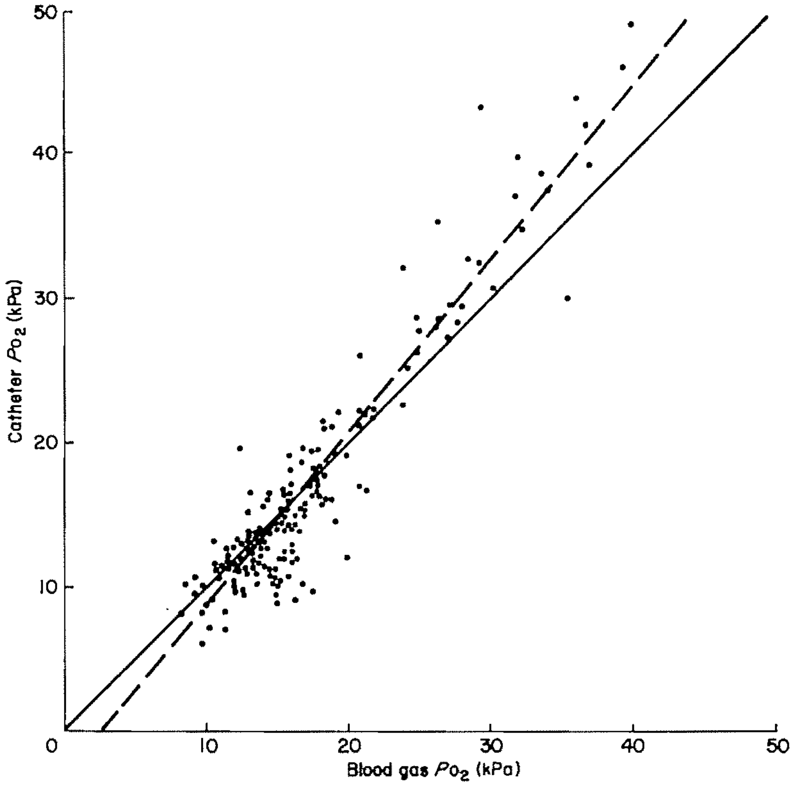

Fig. 4. Plot of CATHP_{O_2} against BGP_{O_2} for all 198 sample pairs with regression line (- - -) and line of identity (——).

CATHP_{O_2} is plotted against BGP_{O_2} with both the regression line and the line of identity shown. The method of Bland and Altman[2] was used to assess more accurately the degree of agreement between the two methods of measurement. The CATHP_{O_2}–BGP_{O_2} differences for all 198 sample pairs were calculated and plotted against the average of the paired P_{aO_2} measurements (Fig. 5). The difference was accentuated at higher values of P_{aO_2} which may reflect the inaccuracy of either or both electrodes. The data for Fig. 6, the frequency distribution of the differences, used only values of BGP_{O_2} in the normal clinical range of 10–20 kPa (154 sample pairs). The mean of the differences was −0.61 kPa (SD 2.24 kPa).

Discussion

Intermittent blood gas sampling can give rise to erroneous results because of leakage and metabolism of oxygen by blood even in syringes immersed in iced water.[3] The error is negligible if the sample is handled carefully and analysed immediately. However alterations can occur with poor sample handling and time delays and are more marked in samples with a high initial BGP_{O_2}. This source of error is eliminated by the use of an intra-arterial electrode. Clark type intra-arterial P_{aO_2} electrodes have been used experimentally for many years. The electrochemical characteristics were described by Eberhard *et al.*[4] and they were used by Goeckenjan[5] to demonstrate rapid and temporal changes after procedures such as tracheal suction and alterations of ventilator settings.

Sensitivity, stabilisation and size are major factors in electrode design. The Continucath electrode is heparin bonded to decrease protein deposition; this should decrease the risk of ischaemic sequelae and help prevent electrode drift. Drift was not a significant factor in our study, and was well below the range of <10% drift over 24 hours

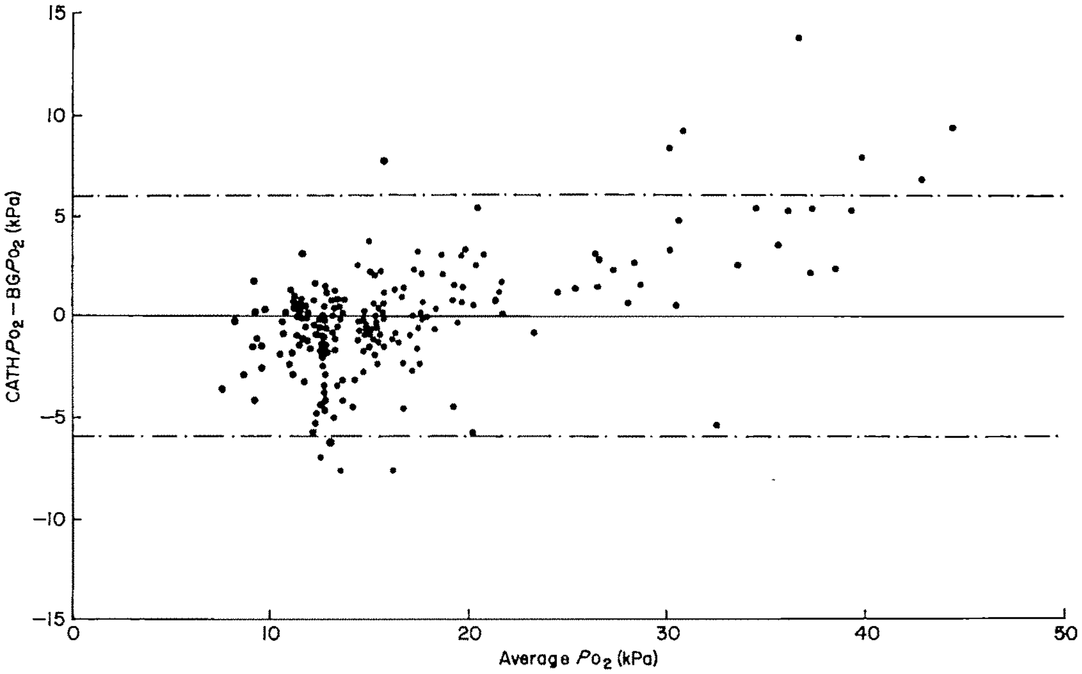

Fig. 5. Scattergram of the CATH$P\mathrm{o}_2$–BG$P\mathrm{o}_2$ differences against the average $P\mathrm{ao}_2$ [(CATH$P\mathrm{o}_2$ + BG$P\mathrm{o}_2$)/2] for all 198 sample pairs with mean (——) and two standard deviations (— • —).

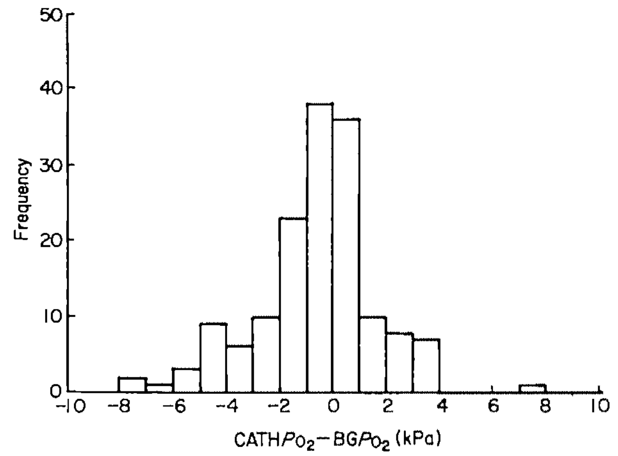

Fig. 6. Histogram to show the frequency distribution of the differences between paired CATH$P\mathrm{o}_2$ and BG$P\mathrm{o}_2$ readings (154 sample pairs from nine patients in whom the BG$P\mathrm{o}_2$ was in the range of 10–20 kPa).

quoted by the manufacturers. The electrode is small and passes through a 20-gauge catheter; catheter size is related to the risk of thrombus formation and occlusion of the artery, although the ratio of catheter to vessel diameter is probably more important.[6] Arai *et al.*[7] monitored $P\mathrm{ao}_2$ continuously during tracheal suction, but their electrode was passed through a 5 FG catheter (16 gauge) into the femoral artery. The electrode assessed by Rithalia *et al.*[8] was also passed through a 16-gauge cannula. An 18-gauge catheter was used by Bratanow *et al.*[9] during normothermic surgery. None of our patients showed any clinically detectable ischaemic problems after cannulation of the radial artery.

Kieraszewicz and Lam[10] assessed an electrode during normothermic hypotensive neurovascular surgery. They reported a poorer correlation between CATH$P\mathrm{o}_2$ and BG$P\mathrm{o}_2$ (r = 0.79) than in the present study (r = 0.96). However, they noted that their electrode erred on the side of safety, i.e. a tendency to warn earlier of hypoxia. Our patients were hypotensive as well as hypothermic during surgery, and this may also be a factor in the altered CATH$P\mathrm{o}_2$/BG$P\mathrm{o}_2$ ratio (Fig. 3). However, the ratio in our patients increased rather than decreased.

The desirability of correcting blood gas measurements for temperature during hypothermic surgery has been debated.[11] The results reported here were corrected to 37°C in order to avoid constant adjustment of the temperature correction dial on the Continucath monitor. The formula shown in the Methods section agrees to within 1.5% with the temperature correction graph shown in the Continucath manual over the range 20–40°C. It should be emphasised that the difference between the two methods is not a measure of the variability of the Continucath alone. The blood gas analyser electrode also varies with time and with different oxygen tensions.

The ratio of CATH$P\mathrm{o}_2$/BG$P\mathrm{o}_2$ deviated markedly from unity during hypothermic surgery (Fig. 3). This deviation may be the result of a slow response time to fluctuating temperature, as not all the catheters showed this effect. Figure 4 demonstrates that there was scatter around the line of identity and that the best fit regression line differs from the line of identity. Figure 5 shows that some of the differences between CATH$P\mathrm{o}_2$ and BG$P\mathrm{o}_2$ were quite large. A recent study by Green *et al.*[12] of the Kontron intra-arterial oxygen electrode showed similar large variations which led them to question its reliability. Our study was aimed specifically to assess the Continucath in a clinical cardiothoracic ITU setting with the nursing staff using the apparatus. The nursing staff usually recorded the Continucath meter readings to the nearest 1 kPa and occasionally to the nearest 0.5 kPa. A more accurate reading could have been obtained by recording an analogue output. They also tended to take their readings at a set hour rather than at an optimal steady-state period. These factors would contribute to some of the differences seen. This paper did not set out to measure the absolute accuracy of the intra-arterial electrode but does show the degree of accuracy that can be expected when it is used in a busy clinical setting by the nursing staff.

The differences were greater when BGPo_2 was high. When the BGPo_2 was between 10 and 20 kPa (Fig. 6) 19% of the Continucath readings differed by more than 3 kPa from the result obtained with the blood gas analyser. The manual of the IL 1302 blood gas analyser reports an accuracy of 0.16 ± 0.13 kPa when measuring blood with a Pao_2 of 12.5 kPa. We would suggest that the intra-arterial electrode is most useful for a continuous display and as a warning monitor. The blood gas analyser is the preferred method to obtain a more reproducible and accurate result.

The authors gained the impression that radial artery catheters with an electrode in place failed earlier than those without an electrode. It was not possible with six out of nine catheters to aspirate a blood sample immediately before removal of the arterial line. Factors which affect patency include the ratio of electrode size to internal catheter diameter. Heparin bonding of the electrode to prevent platelet and protein adhesion has been described by Nilsson *et al.*[13] Variation in the effectiveness of this bonding may be a factor which promotes blockage but variation in the coagulability of the patient's blood is more likely. Trauma as a result of heavy usage may also play a part. Normally, the use of the catheter will reduce the need to take blood samples. An average of 29 samples was withdrawn during this study, and it is likely that this large sample number was in some part responsible for the high blockage rate.

Some damping of the arterial wave form was noted by the authors. The factors which predispose to blockage could also affect the degree of damping; episodic factors such as wrist position and saline flushing of the catheter made its occurrence variable.

This study found that the newly available continuous intra-arterial Pao_2 electrode was easy to insert and practical in use. A good correlation was found with the Pao_2 derived from a blood gas analyser but there was a marked degree of variability. The absolute value derived from the Continucath monitor depends on the accuracy of the initial calibration. There were no ischaemic problems on clinical examination of the hand after the use of these catheters. It is perhaps the first stage in the development of multiple *in vivo* electrodes for many parameters such as Pao_2, potassium,[14] pH and carbon dioxide.

References

1. Oxorn DC, Chung DC, Lam AM. Continuous in-vivo monitoring of arterial oxygen tension in a patient treated with bleomycin. *Canadian Anaesthetists' Society Journal* 1984; **31:** 200–5.
2. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986; **1:** 307–10.
3. Restall RVF, Miller SE, Hahn CEW, Epstein HG, Foex P. Plastic or glass syringes: a comparison of the changes in oxygen tension when blood or water samples are stored in iced water. *British Journal of Anaesthesia* 1975; **47:** 636–7.
4. Eberhard P, Fehlmann W, Mindt W. An electrochemical sensor for continuous intravascular oxygen monitoring. *Biotelemetry and Patient Monitoring* 1979; **6:** 16–31.
5. Goeckenjan G. Continuous measurement of arterial Po_2. Significance and indication in intensive care. *Biotelemetry and Patient Monitoring* 1979; **6:** 51–65.
6. Bedford RF. Radial arterial function following percutaneous cannulation with 18- and 20-gauge catheters. *Anesthesiology* 1977; **47:** 37–9.
7. Arai T, Hatano Y, Komatsu K, Takada T, Miyake C, Harioka T, Reshad K. Real-time analysis of the change in arterial oxygen tension during endotracheal suction with a fibreoptic bronchoscope. *Critical Care Medicine* 1985; **13:** 855–8.
8. Rithalia SVS, Bennett PJ, Tinker J. The performance characteristics of an intra-arterial oxygen electrode. *Intensive Care Medicine* 1981; **7:** 305–7.
9. Bratanow N, Polk K, Bland R, Kram HB, Lee T-S, Shoemaker WC. Continuous polarographic monitoring of intra-arterial oxygen in the perioperative period. *Critical Care Medicine* 1985; **13:** 859–60.
10. Kieraszewicz HT, Lam AM. Continuous monitoring of oxygenation during hypotensive anaesthesia—evaluation of an intravascular Po_2 electrode. *Canadian Anaesthetists' Society Journal* 1983; **30:** S62.
11. Ream AK, Reitz BA, Silverberg G. Temperature correction of Pco_2 and pH in estimating acid-base status: an example of the Emperor's new clothes? *Anesthesiology* 1982; **56:** 41–4.
12. Green GE, Hassell KT, Mahutte CK. Comparison of arterial blood gas with continuous intra-arterial and transcutaneous Po_2 sensors in adult critically ill patients. *Critical Care Medicine* 1987; **15:** 491–4.
13. Nilsson E, Alme B, Edwall G, Larsson R, Olsson P. Continuous intra-arterial Po_2 registrations with conventional and surface heparinised catheter electrodes. In: HP Kimmich, Nijmegen, eds. *Monitoring of vital parameters during extracorporeal circulation.* Basel: S. Karger, 1981: 48–52.
14. Drake HF, Treasure T, Smith B. Continuous display of plasma potassium during cardiac surgery. *Anaesthesia* 1987; **42:** 23–9.

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APPARATUS

Tracheal tubes in cold stress

B.-E. DAHLGREN, H. G. NILSSON AND B. VIKLUND

Summary

During rescues in cold climates, plastic tracheal tubes have fractured because of cold stress or mishandling. Susceptibility of rubber and plastic tracheal tubes to cold stress was tested in a climate chamber. Plastic tubes became stiffer when chilled, had greater resistance to reshaping and were more sensitive to shock and manipulation. They also need protection against cold and shock during transport. Rubber tubes were more tolerant of cold stress. Very cold rubber and plastic tubes may induce tissue damage. Rewarming to a nondangerous temperature was shown to be a quick procedure. It is suggested that the rescuer's own body heat be used.

Key words

Equipment; tubes, tracheal.
Temperature; cooling.

The frequency of use of Advanced Life Support (ALS), which includes tracheal intubation at the accident scene, has increased during the last decade, and continues to be performed under adverse conditions. Nurses and doctors have noticed, however, that plastic tracheal tubes become difficult to handle on these occasions because of cold stress. They are stiffer than at ordinary room temperature, more susceptible to trauma and even fracture; their cuffs are hard to inflate and less tolerant to handle.

The purpose of this study was to investigate, by controlled laboratory tests, the rough differences between plastic and rubber tracheal tubes under cold stress. The tests used were chosen in order to simulate the procedure of tracheal tube handling in rescue medicine.

Methods

Tracheal tubes available on the Swedish market were studied. The plastic ones were manufactured by Mallinckrodt, Portex and Vygon, the rubber, by Rüsch. Three randomly selected samples out of ordinary batches of sizes 7.0, 8.0 and 9.0 were used.

Reshaping of the tracheal tubes

Experiments on the force required to reshape tracheal tubes for the pharyngeal and laryngeal cavity have been studied by Stenqvist *et al.*[1] We measured the force needed to reshape a tracheal tube to the contour of a Portex preformed 8.0-mm size tube. The tubes were attached to a rack at the 'oral' and 'tracheal' ends and a peg was used to simulate the base of the tongue. A load was attached to the tubes with a 20-mm broad strap, its centre 30 mm above the upper cuff margin (Fig. 1). Loading was performed by a dynamometer until the curvature of the tube conformed to the Portex preformed no. 8 at different temperature levels (+20, +10, 0, −10, −20°C). The cold stress was achieved in a climate chamber at the Aircrew Performance and Function Division, Swedish Defence Research Institute.

Elasticity of the cuff

The cuffs were insufflated with the same volume of air at the different temperatures studied. The increase in pressure produced by the insufflation of air was recorded at intervals from +20°C down to −20°.

Deformation tests

Deformation tests were performed at −20°C as follows: sufficient pressure was applied in order to make contact between the interior walls of the tube; the tubes were bent around a 1-cm metal rod (approx 180° curvature); a very gentle pulling force was applied to the cuff insufflation catheter to test the adhesive-point at the tube; the cuff adapter and air lock were squeezed by forceps.

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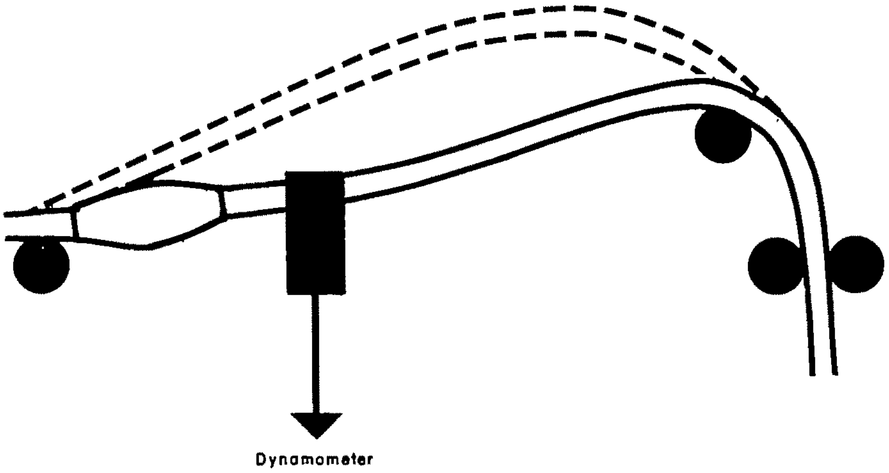

Fig. 1. Principle of the rack used to test the reshaping. ●, supportive pegs; = = =, normal shape of the tracheal tube.

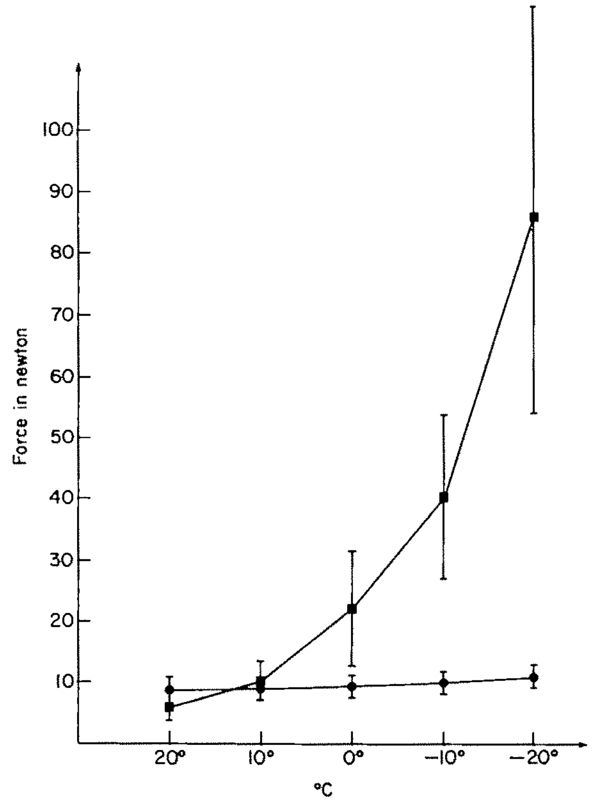

Fig. 2. Mean (SD) force in newtons needed to reshape the tubes. ■, plastic tubes; ●, rubber tubes. Plastic, $n = 3 \times 3 \times 3 \times = 27$, rubber, $n = 3 \times 3 = 9$.

Rewarming

Rewarming of the tracheal tubes, chilled to −20°C, was performed in a water bath at +37°C.

Results

Reshaping of tracheal tubes (Fig. 2)

The force necessary to reshape the rubber increased very little (2 N) as the temperature decreased. The plastic tubes became stiffer as the temperature was reduced and the force at −20°C had increased from about 5 N to 8 N.

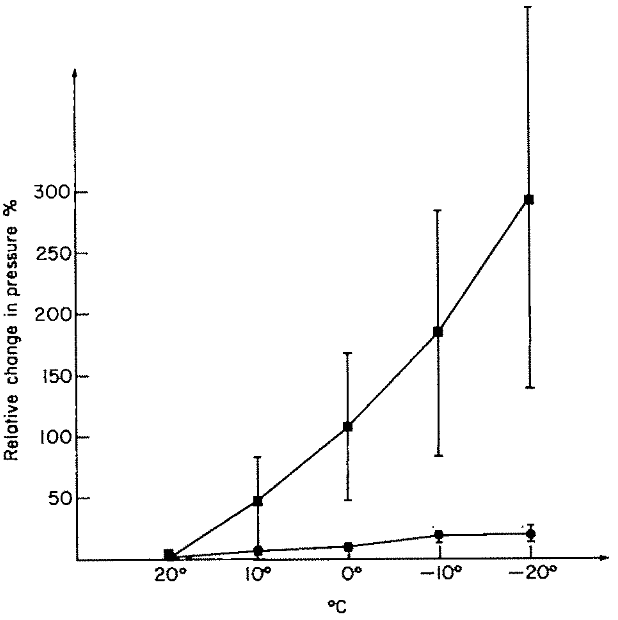

Fig. 3. Elasticity of the cuff. Pressure change expressed as mean % (SD) of pressure at +20°C. ■, plastic tube; ●, rubber tube. Plastic, $n = 27$; rubber, $n = 9$.

Elasticity of the cuff (Fig. 3)

The elasticity of the cuff used with the plastic tubes was greatly reduced as temperature decreased; changes were far less noticeable in the cuff used with the rubber tubes.

Deformation test (Table 1)

The rubber tubes showed no signs of damage after the deformation test. However, many plastic tubes were cracked after compression at −20°C and were so badly impaired that they could not be used. The same poor results were obtained when the plastic tubes' cuff adapter was gently pulled and squeezed. Squeezing the cuff adapter showed similar results except in the Vygon tubes. Gentle pulling also disconnected the insufflation catheter in the majority of tests with the plastic tubes. No such results were found when rubber tubes were tested.

Table 1. Deformation tests performed at −20°C.

	Mallinckrodt (plastic) $n = 9$	Portex (plastic) $n = 9$	Vygon (plastic) $n = 9$	Rüsch (rubber) $n = 9$
Interial wall contact	2 cracked	2 cracked	3 cracked	0
Bending (180°)	0	4 persistent impression	0	0
Gentle pulling of cuff catheter	8 disconnected	9 disconnected	6 disconnected	0
Forceps squeezing	9 cracked	9 cracked	0	0

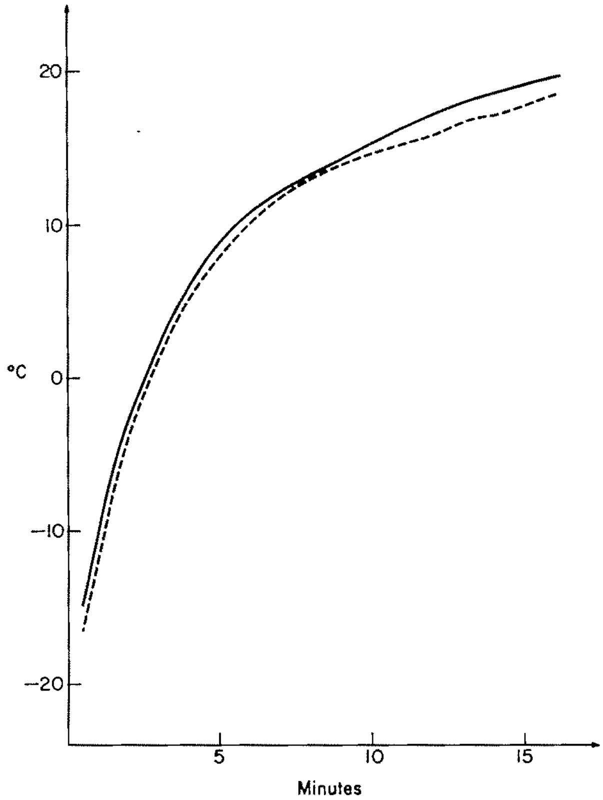

Fig. 4. Rewarming time in room temperature (+21°C). ----, rubber; —— plastic. Only the lowest value is plotted. Plastic, $n = 3$; rubber, $n = 3$; range, 0.5°C.

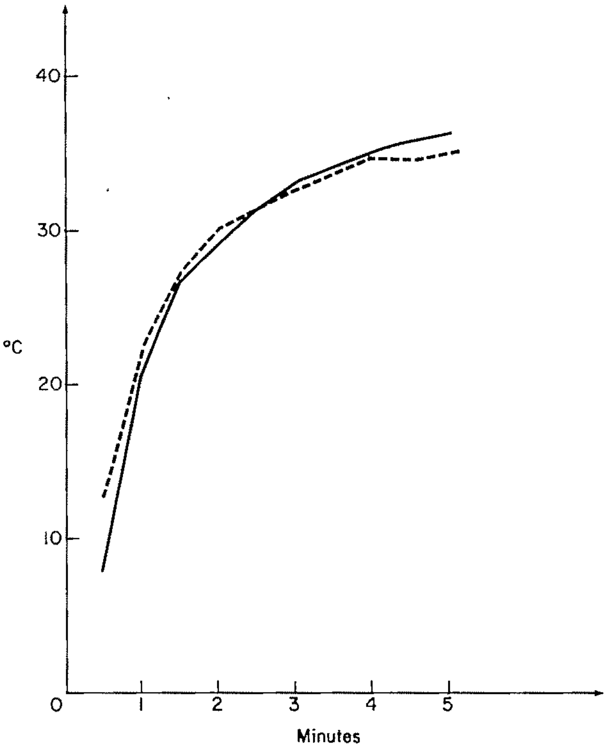

Fig. 5. Rewarming time in water bath 37°C. ----, rubber 9.0; ——, plastic 9.0. Only the lowest value is plotted. Plastic, $n = 3$; rubber, $n = 3$; range 0.5°C.

Rewarming (Figs 4 and 5)

Both rubber and plastic tubes were quickly rewarmed from −20°C to room temperature and to body temperature. There was no great difference between the two groups; nor was there any change in the quality of the tubes when a superficial comparison was made before, during, and after cold stress followed by rewarming.

Discussion

In Sweden there are great temperature variations between geographical areas and between seasons. In order to select appropriate tracheal tubes for use in rescue medicine under a range of weather conditions standardised tests were needed. The climate chambers produced reliable test conditions in which any type of weather could be simulated.[1] Ordinary handling of tracheal tubes in rescue medicine was studied and because the tests had been used previously,[2] this allowed comparisons to be made. Each make of plastic tube was tested separately during the study. Only minor differences were found and therefore a plastic tube series was used in the comparison. The pulling force when the connexion of the cuff inflation catheter and the tube were tested was described as gentle, which means that even a minor manipulation was sufficient to cause damage.

The physical properties of the plastic materials explains the force required to reshape, susceptibility to minor manipulation and decreased elasticity in the cuff of the plastic tubes. The great difference registered in cuff pressure might be because the plastic tubes had high volume cuffs; the rubber tubes had ordinary cuffs. These findings show that appliances made of plastic have to be very carefully insulated against exposure to cold during transport and at the accident scene. The bags used for equipment transportation should offer good protection against shock: apparatus and appliances must be arranged in the bag so that dressing material can be used as an insulator and for shock absorption. The bag's contents must be put in a safe place at the accident scene otherwise the rescuer or others in the stressed situation may very easily and unintentionally step on the more fragile equipment.

During transport or storage in a cold environment the equipment will very soon be chilled to temperatures below zero.[1] This may cause the tubes not only to shatter, but used invasively such equipment may produce local damage to the patient. Close contact with a chilled tracheal tube could injure vocal cords and other laryngeal structures. Problems with tube deformation was recognised by Lindholm in normothermic patients.[3] The increased stiffness of plastic tracheal tubes might make intubation more difficult and their reduced elasticity may lead to the cuff needing large volumes of air to achieve air tightness. Increased cuff volume will produce greater mucosal pressure when tubes are rewarmed; the cuff pressure should therefore be checked several times after intubation, especially in hypothermic patients. Intubation difficulties and damage when the tube is reshaped can easily be avoided if the tracheal tube is rewarmed before it is used. The rescuer can use his own body heat for this purpose and put a number of tubes next to his body on arrival at the accident scene.

Conclusion

The study has shown that rubber tracheal tubes are preferable to plastic tubes when subjected to cold stress. Plastic tubes showed greater resistance to reshaping and also greater susceptibility to shock or manipulation when chilled. Therefore plastic tubes have to be very well protected during transport and then thoroughly scrutinised before use. It is very important to rewarm tracheal tubes because chilled tubes might damage the pharyngeal mucosa, vocal cords or other structures. Both rubber and plastic tubes rewarm very quickly. The general recommendation is that rubber tracheal tubes be used in rescue medicine in countries with a climate similar to that of Sweden.

References

1. Dahlgren B-E, Engdahl O, Nilsson HG. Portable emergency ventilators sensitivity to environment. *Acta Anaesthesia Scandanavica* 1981; **25:** 46–50.
2. Stenqvist O, Sonander H, Nilsson K. Small endotracheal tubes. *British Journal of Anaesthesia* 1979; **51:** 375–80.
3. Lindholm C-E, Carroll RG. Evaluation of tube deformation pressure in vitro. *Critical Care Medicine* 1975; **3:** 196.

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APPARATUS

Evaluation of a new tracheal tube with a movable bronchus blocker

R. G. MacGILLIVRAY

Summary

A new tracheal tube which incorporates a movable bronchus blocker (the Univent tube), was evaluated in eight patients who underwent thoracic surgery. Difficulties encountered with accurate placement suggest that routine use should be made of a fibreoptic bronchoscope to confirm the position of the blocker.

Key words

Equipment; tubes, tracheal, bronchial.
Anaesthesia; thoracic.

Isolation of all or part of a lung may be required for a variety of reasons in thoracic surgery and intensive care. Indications include the need to prevent soiling of the uninvolved lung (by blood, pus, secretions or lavage fluid); to allow effective ventilation (in the presence of airway disruption, massive cyst/bulla or bronchopleurocutaneous fistula); or to facilitate surgical exposure.[1] The Univent tube (Fuji Systems Corporation),[2–6] a tracheal tube which incorporates a movable bronchus blocker, is a recent development for these indications.

Apparatus

The Univent is a silastic tracheal tube of normal configuration with a separate channel in the anterior, internal wall. This channel contains a bronchial blocker with a low pressure, high volume cuff at its tip and a lumen of internal diameter 2 mm (Fig. 1). The blocker is retracted into the side channel when the tube is introduced into the patient's trachea. From this position the blocker can be extended up to 8 cm beyond the tip of the main tube, and because of its angulation, it may be directed into one or other mainstem bronchus either by rotation of its proximal end or by rotation of the whole tube assembly. A seal can be obtained, and the lung, lobe or segment isolated by inflation of the cuff. The blocker lumen can be used for suction or gas insufflation as indicated, while the tracheal lumen is used in the conventional manner. Four sizes of Univent tube are available; 31, 33, 35 and 37 French gauge (FG).

Methods

Eight adult patients scheduled for thoracic surgery gave their consent to the use of a Univent tube. Patient characteristics are shown in Table 1. Anaesthesia was induced, after pre-oxygenation, with fentanyl 2–3 μg/kg, thiopentone 4–5 mg/kg and suxamethonium 1 mg/kg, and the trachea was intubated by the author using a Univent tube. Anaesthesia was maintained with controlled ventilation with nitrous oxide 50% in oxygen and 0.5–1% halothane, when the tube had been secured in the trachea.

Table 1. Patient characteristics.

Patient	Age	Sex	Operation	Univent size (FG)
1	43	M	Left lower lobectomy (bronchiectasis)	37
2	56	M	Left upper lobectomy (bronchiectasis)	37
3	29	F	Right decortication (empyema)	31
4	53	F	Right lower lobectomy (tumour)	31
5	21	M	Left lower lobectomy (bronchiectasis)	35
6	37	F	Left decortication (empyema)	31
7	34	M	Left decortication (post-traumatic)	35
8	28	F	Right lower lobectomy (bronchiectasis)	31

Introduction of the bronchus blocker to the left (five patients) or right (three patients) mainstem bronchus was attempted according to the manufacturers' recommendation of rotation of the proximal end of the blocker, after confirmation by auscultation of satisfactory bilateral air entry. The cuff was inflated when it was thought that the blocker had been placed in the desired position and efficacy of the seal was tested by auscultation of the chest; attach-

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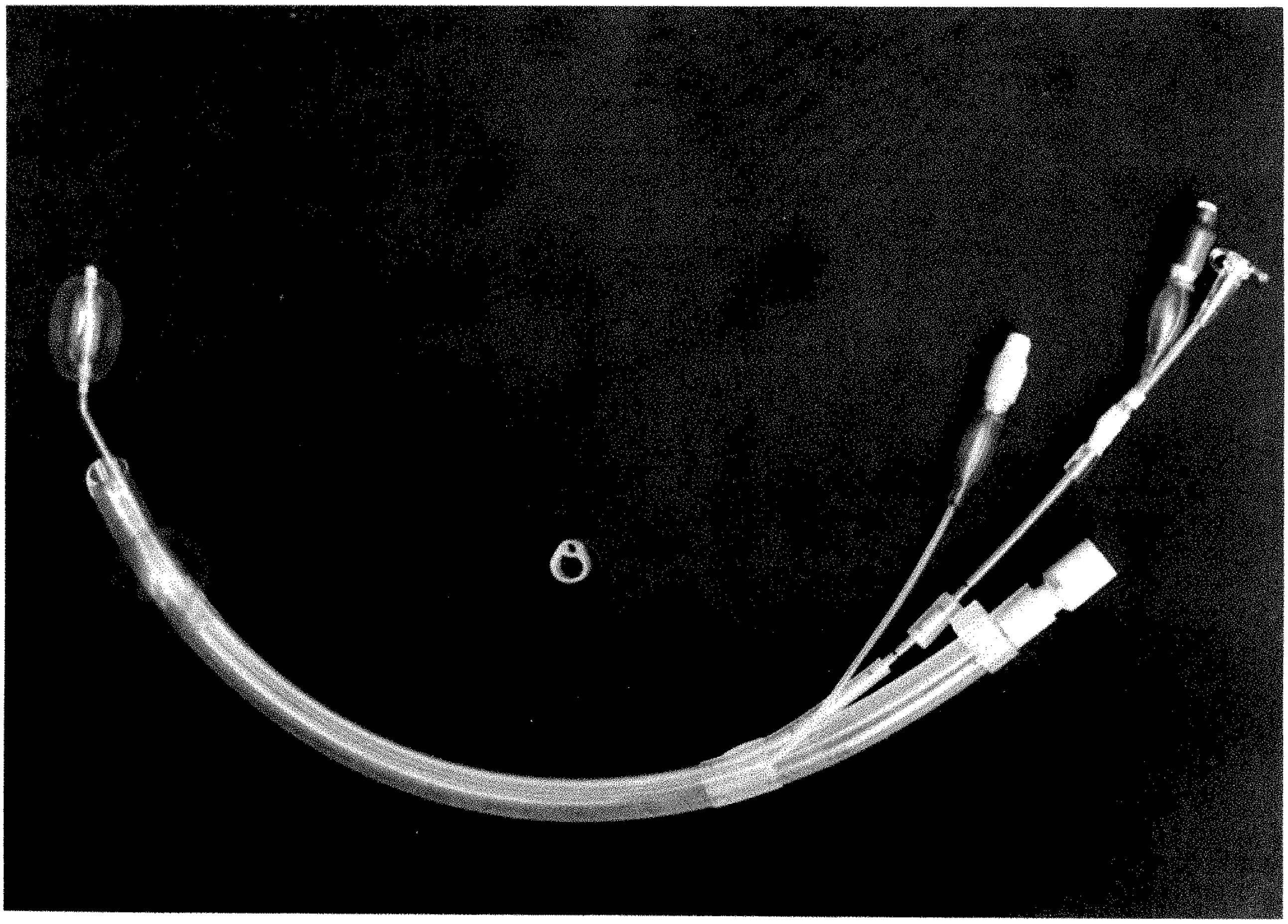

Fig. 1. Tracheal tube with movable bronchus blocker in separate channel in internal curve.

ment of an underwater seal;[7] and attachment of a capnogram to the blocker lumen.[8]

The position of the blocker was checked, when placement was thought to be satisfactory, by visualisation with a flexible fibreoptic bronchoscope (Olympus LF-I) introduced via the tracheal lumen. Any further adjustments in position were undertaken under direct vision.

Results

Eight Univent tubes were placed, four of 31 FG, two of 35 FG and two of 37 FG. Blind introduction of the bronchus blocker to effect a satisfactory seal was unsuccessful in seven out of eight attempts. Further manipulation under direct vision by fibreoptic bronchoscopy in these seven patients led to successful seal in four; however in two of these a minor leak became evident during surgery. A satisfactory seal could not be obtained in the remaining three; in one, there was a persistent leak, and in two the cuff of the blocker herniated back into the trachea and caused partial obstruction of the residual airway. The Univent was removed in these three patients and replaced with an appropriate size PVC double lumen tube.

Table 2 shows the Univent tube sizes as designated by the manufacturers, compared to the equivalent PVC double lumen Bronchocaths (National Catheter Corporation). Recent examples of the Univent also include a statement on internal and external diameters which are compared in Table 2 to the external diameters of single lumen tubes of the same internal diameters (Shiley).

Table 2. Comparative tube sizes.

Univent FG	Equivalent DLT, FG	Univent ID, mm	Univent OD, mm lateral/AP	Equivalent SLT OD, mm
31	35	7.5	11.0/12.0	9.6
33	37	8.0	11.5/13.0	10.9
35	39	8.5	12.0/13.5	11.6
37	41	9.0	12.5/14.0	12.2

DLT, double lumen tube, Bronchocath; SLT, single lumen tube, Shiley; AP, anteroposterior; ID, internal diameter; OD, outside diameter.

Discussion

The Department of Anaesthetics, University of Natal, provides anaesthetic services for the thoracic surgical units at the Wentworth and King George V Hospitals, Durban, which together are responsible for over 800 major noncardiac thoracic surgical procedures annually. Most of these operations require lung isolation techniques, and any new advances in this field are scrutinised closely to determine their potential application in improvement of patient care.

There have been a number of favourable reports on the Univent tube in the literature,[2–6] three from the designer in Japan and two from one unit in the USA. The advantages claimed include a larger tracheal lumen than conventional double lumen tubes, and, because double lumen tubes merely separate right from left, the facility with this tube to block selectively a lobar or even segmental bronchus.

Ease of placement is another claimed advantage; however, it has not been confirmed by this study. Only one of eight tubes was positioned satisfactorily by an experienced thoracic anaesthetist, who followed the manufacturers' recommendations. It is not possible to control the direction of the angled blocker tip by manipulation of its proximal end. An alternative proposed method of blind introduction[2,3,6] involves rotation of the whole tracheal tube assembly; however, this method was also found to be unsatisfactory, because of the preformed curve in the tube.

Fibreoptic bronchoscopy is thus mandatory for the placement of the blocker and confirmation of a seal. This provides no advantage over conventional double lumen tubes with regard to ease or speed of placement in emergency situations. The small cap at the tip of the blocker is hard, and excoriation of the tracheal mucosa after attempts at blind introduction has been observed at bronchoscopy. A recent report describes how one such cap became dislodged on advancement of the blocker;[9] fortuitously this was noticed immediately and the cap was retrieved successfully with a biopsy forceps passed through the suction channel of the bronchoscope.

Attempts to effect a seal in two patients by inflation of the blocker cuff resulted in herniation of the cuff back up the airway. The bronchi are not parallel-sided structures but taper towards the periphery. The large volume cuff of the Univent requires twice as much air as the cuffs of conventional double lumen tubes (Table 3) to achieve the same seal because of the narrow lumen of the blocker; this large volume of air predisposes to herniation.

Table 3. Equivalent volumes of bronchial cuffs.

Univent blocker	5 ml
Bronchocath 39	2 ml
Portex 5.5	2.5 ml
Carlens 39 (Rusch)	2.5 ml
Robertshaw medium (Leymed)	2 ml

The designation of tube size is also a source of some confusion. French gauge represents the external diameter of a tube in mm multiplied by three.[10] Table 2 demonstrates a discrepancy in sizes such that tube selection, if made according to recommendations or experience with other tubes (e.g. Bronchocath), may be inappropriate. It should be noted that the smallest Univent has an external diameter equivalent to a 9.0 mm conventional single lumen tube (Shiley); thus failure to intubate a 'small' patient should come as no surprise.[6]

The use of silastic as a material for tracheal tube construction adds significant expense without seeming to confer any advantages over polyvinylchloride.

Conclusion

It is recognised that a learning curve exists for any new technique; however this evaluation suggests that this device, while attractive in concept, offers no real advantage over conventional double lumen tubes. It may be imprudent to attempt the use of these expensive tubes in an emergency situation.

Acknowledgments

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References

1. WILSON RS. Thoracic anesthesia. *Seminars in Anesthesia* 1987; **6:** 10–6.
2. INOUE H, SHOHTSU A, OGAWA J, KAWADA S, KOIDE S. New device for one-lung anesthesia: endotracheal tube with movable blocker. *Journal of Thoracic and Cardiovascular Surgery* 1982; **83:** 940–1.
3. INOUE H, SHOHTSU A, OGAWA J. New device for one-lung anesthesia: endotracheal tube with movable blocker. *Medical Apparatus News* 1982; **3:** 8–11.
4. INOUE H, SHOHTSU A, OGAWA J, KOIDE S, KAWADA S. Endotracheal tube with movable blocker to prevent aspiration of intratracheal bleeding. *Annals of Thoracic Surgery* 1984; **37:** 497–9.
5. KAMAYA H, KRISHNA PR. New endotracheal tube (Univent Tube®) for selective blockade of one lung. *Anesthesiology* 1985; **63:** 342–3.
6. HULTGREN BL, KRISHNA PR, KAMAYA H. A new tube for one lung ventilation: experience with Univent tube. *Anesthesiology* 1986; **65:** A481.
7. DUNNE NM, GILLBE CE. Endobronchial apparatus and its intraoperative management. In: GOTHARD JWW, ed. *Bailliere's clinical anesthesiology. Thoracic anaesthesia. Vol. 1.* London: Bailliere Tindall, 1987: 79–98.
8. SHAFIEHA MJ, SIT J, KARTHA R, SABRIS L, HAJNIANPOUR B, PAPPAS AL, YU E, ELAM J, BALAGOT RC. End-tidal CO_2 analyzers in proper positioning of the double-lumen tubes. *Anesthesiology* 1986; **64:** 844–5.
9. ARAI T, HATANO Y. Yet another reason to use a fiberoptic bronchoscope to properly site a double lumen tube. *Anesthesiology* 1987; **66:** 581–2.
10. DORSCH JA, DORSCH SE. *Understanding anesthesia equipment.* Baltimore: Williams and Wilkins, 1982: 361.

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Forum

A survey of anaesthetic charts

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Summary

This survey reviews the structure and content of all anaesthetic record charts in use in the 40 hospitals of the Yorkshire Regional Health Authority in the light of previous recommendations. Twenty-two different anaesthetic charts were used by 290 anaesthetists in this region. Some of the charts did not meet the ideal standard for size (A4) and the majority had no colour coding. Fourteen of the 22 charts omitted important headings concerned with patient identification and eight charts did not provide a record of the whole perioperative period. Some comprehensive forms are in use, chiefly in smaller hospitals, but there have been few changes in design in the last 10 years despite increasing medicolegal awareness.

Key words

Records, anaesthesia.

It is more than a decade since a report[1] was published on anaesthetic records in Great Britain and Ireland in which it was recommended that detailed records should be kept of the whole perioperative period. These records should be on a standardised chart with colour coding and should have a grid with a time base for charting incremental drug dosages and vital signs. Important patient identification data and operative data should also be included. The Nuffield Provincial Hospitals Trust subsequently published a report[2] on mortality associated with anaesthesia; the clinical and legal implications of inadequate anaesthetic record keeping were highlighted by the authors.

Increasing numbers of high risk patients present for anaesthesia. In addition, monitoring techniques have become more complex and there is a heightened public awareness of litigation. Consequently, it is of paramount importance to keep clear and comprehensive notes of every patient's pre-operative condition, peroperative course and postoperative progress. Record sheets should be easily identified and readily available in the event of readmission for further surgery and anaesthesia.

We analysed the charts in current use by anaesthetists who work in the Yorkshire Regional Health Authority to identify the extent to which previous recommendations had been adopted.

Method

The authors contacted a member of each anaesthetic division in the Yorkshire Regional Health Authority, and requested a copy of every anaesthetic chart in use in their hospitals. Initial nonresponders were contacted personally and eventually a 100% response was achieved. Charts used specifically for obstetric anaesthesia were not requested.

Results

The anaesthetic record charts reviewed were used by 290 anaesthetists of all career grades, and by associate specialists and clinical assistants. The charts were obtained from 40 hospitals in 16 health authorities; two of these are teaching authorities. Four health authorities, including both teaching authorities, use more than one type of chart. A total of 24 charts were returned, but two pairs used in hospitals in adjacent areas were identical. Thus, 22 different charts were in use. One chart was used only for cardiothoracic anaesthesia, but we have included it in the results and made comments where appropriate. No separate pre-operative or postoperative charts were sent to us.

Colour code. Fourteen charts had no colour coding to aid location amongst the patient's notes. Of the eight with a colour code, the whole sheet was a different colour in five and there was a marginal colour code in three.

Size. Nineteen charts were approximately A4 size (21.0 × 29.7 cm) but the width ranged from 19.1 to 21.2 cm and length from 29.2 cm to 31.0 cm. Five charts were printed on one side only, 13 on two sides and four on four sides. One form (printed on one side only) had a carbon copy available; this was the specialised cardiothoracic form.

Consent. The consent form was included on eight charts, and in one other there was a space to indicate that the separate consent form had been checked. In addition, three charts included a drug therapy form to be signed by the patient; this related to the pre-operative use of steroids or psychotropic drugs. Two charts, both from the regional burns unit, included a form for consent of minors to burns treatment.

Patient details. Only six charts had a space for an identification label such as an addressograph. The details of patient identification and administrative data recorded on the charts are shown in Table 1.

Diagnosis and intended operation. Two charts had no space to record the date of operation, two had no space for the name of the anaesthetist and three had no space for the surgeon's name. The pre-operative diagnosis was noted on only one chart. The operative details recorded on the charts are shown in Table 2.

Pre-operative assessment. The lack of space for pre-

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Table 1. Patient identification and administrative data. No chart had details of marital state, religion, occupation or GP's name.

Patient name	77.3%
Hospital number	68.2%
Date of birth/age	63.6%
Ward number	40.9%
Addressograph	27.3%
Sex	18.2%
Address	4.5%

Table 2. Operative details recorded. No chart had space for the grade of surgeon or anaesthetist.

Date of operation	90.9%
Name of surgeon	86.4%
Operation performed	86.4%
Name of anaesthetist	81.8%
Hospital name	72.7%
Operation proposed	45.5%
Signature of anaesthetist	22.7%
Duration of anaesthesia	9.1%
Theatre number	4.5%
Diagnosis	4.5%
Consultant surgeon in charge	4.5%
Duration of operation	4.5%

Table 3. Incidence of specific pre-operative details.

Weight	54.5%
Fitness grade	36.4%
Drugs history	36.4%
Allergies	27.3%
Elective/emergency	22.7%
Past anaesthetic history	18.2%
Dental chart	13.6%
Past medical history	9.1%
Time starved	4.5%
Family history	4.5%
Surface area	4.5%

operative details was highlighted by the fact that six charts had no space for pre-operative assessment and two had one line or less. The space provided for pre-operative assessment in the remaining 16 charts ranged from 11 to 483 sq cm (2%–77% of A4 size). Nine had a structured format with headings (shown in Tables 3, 4 and 5) to act as *aides memoire*.

Pre-operative medication. A space to prescribe pre-operative medication was included in 18 charts and a further two showed the drugs used but not the dose given.

Table 4. The use of systematic headings in the pre-operative assessment.

Arterial pressure	59.1%	Central nervous system	4.5%*
Heart rate	31.8%	Gastrointestinal system	4.5%*
Cardiovascular system	31.8%	Genitourinary system	4.5%*
Respiratory system	31.8%	Endocrine/metabolic	4.5%*

* Same form.

Table 5. Headings used for noting pre-operative investigations. No chart had space to note the Sickledex result.

Haemoglobin and full blood count	59.1%
Urine	27.3%
Urea and electrolytes	18.2%
Blood group	18.2%
Chest X ray	13.6%
Blood available	9.1%
ECG	9.1%
Temperature	9.1%
Blood gas analysis	4.5%
Pulmonary function tests	4.5%

Table 6. Premedication details.

Space to prescribe premedication	81.8%	90.9%
Space to note premedication	9.1%	
Person who ordered premedication	31.8%	
Time ordered	31.8%	
Time given	31.8%	
Person who gave premedication	27.3%	
Effect of premedication	27.3%	

Table 7. The size of the grid for charting intra-operative details. The size 151–200 sq cm represents approximately half A4 size.

Area (sq cm)	Number of forms
101–150	4
151–200	8
201–250	2
251–300	4
301–350	0
351	1

The details of pre-operative medication noted are shown in Table 6.

Intra-operative data. Two charts had a plain, unstructured sheet for details of the anaesthetic, six had a plain sheet and a grid, one had structured headings (no grid) and 13 contained a structured sheet with headings and a grid. The size of the grid for charting intra-operative details ranged from 101–368 sq cm (16% to 60% of A4 size) (Table 7). Five of the 19 charts with a grid had figures only on the vertical axis, four had figures and headings and nine had figures, headings and symbols. One had a grid only with no other printed details. The specific headings/spaces which were printed on the grids are shown in Table 8. The headings used on charts which were structured are shown in Table 9. The only chart which detailed either monitoring techniques or the urine output was the chart in use at the specialist cardiothoracic centre.

Postoperative details. Space for postoperative observations and/or instructions was included in 14 charts; detailed

Table 8. Details of specific headings used on the intra-operative grid.

Arterial pressure/pulse	59.1%
Drugs	40.9%
Respiratory rate	36.4%
Central venous pressure	18.2%
Temperature	18.2%
Fluids/blood	18.2%
Oxygen %	9.1%
Volatile agent	4.5%

Table 9. Various headings used to structure the intra-operative space.

Complications	59.1%	
Fluids/blood given	50.0%	
Airway maintenance technique	40.9%	
Induction techniques and doses	36.4%	
Tracheal tube size	36.4%	
Maintenance technique	31.8%	
Intravenous site used	27.3%	
Throat pack	27.3%	
Operative blood loss	27.3%	
Local/regional techniques used	18.2%	
Patient position	13.6%	
Reversal agents	13.6%	
Ventilator controls	13.6%	
Tourniquet time	9.1%	
Urine output	4.5%	same hospital
Monitoring used	4.5%	

Table 10. Recording of postoperative details.

Postoperative instructions	45.5%
Postoperative observations	27.3%
Postoperative fluids	27.3%
Postoperative analgesics	22.7%
Condition on leaving theatre	18.2%
Surgical instructions	13.6%
Postoperative oxygen therapy	9.1%
Position for nursing	9.1%
Drain instructions	4.5%
Antibiotic instructions	4.5%
Postoperative progress	4.5%

headings are shown in Table 10. A grid for postoperative observations was provided in only two charts and in only three was there space to chart one or two readings.

Discussion

Seed and Welsh[1] attempted in 1976 to ascertain some of the common features of anaesthetic record charts in Great Britain and Ireland. They analysed 206 different charts and although no attempt was made to offer an ideal chart, they hoped that the information generated would assist anaesthetists who wished to create their own design. They concluded that many features of the charts were similar, but that important aspects were omitted on some, whilst others had too many options which were not necessarily relevant to the administration of an anaesthetic. The patient's name, hospital number, date of operation, name of surgeon, operation performed and name of anaesthetist were all considered to be important, as was the effect of the pre-operative medication and the facility to note adverse reactions, complications or difficulties. They believed that space for information, including investigations, normally found elsewhere in the patient's notes, was unnecessary. That survey also highlighted the recommendations of a subcommittee of the Association of Anaesthetists of Great Britain and Ireland and the subcommittee on the standardisation of hospital medical records;[3] both groups urged the use of an anaesthetic record chart of A4 size. The subcommittee of the Association of Anaesthetists, chaired by Professor W.W. Mushin, met in 1965 and suggested a standard anaesthetic record form for use by anaesthetists who worked in hospitals where there were no existing charts. The proposed chart was colour coded, had a grid with a time base for recording vital functions and space for the postoperative recovery period. Unfortunately, the minutes of this subcommittee meeting are no longer available and the recommended chart did not gain widespread acceptance. Neither the Association nor the Faculty of Anaesthetists have provided any more recent recommendations on the design, content or format of the anaesthetic record chart.

The present survey reviewed the anaesthetic record charts used in the Yorkshire region, a large regional health authority which cares for more than 3.6 million people and which probably provides a reasonably representative sample of contemporary anaesthetic practice in the United Kingdom. The most surprising finding in this study was the paucity of anaesthetic record charts which had incorporated the recommendations made more than 10 years ago and we found it disturbing that there were a number which lacked any structure. However, some comprehensive, well designed, ones were in use, chiefly in hospitals with a small number of consultant anaesthetists. This probably reflects the diversity of opinion on the design of these charts and the difficulty in obtaining agreement within larger departments.

The use of colour coding, as suggested by the Association of Anaesthetists, had still not been adopted widely. It is important that previous anaesthetic records should be located easily in the notes and it is useful to have the whole sheet or sheets in a different colour. A standard colour for anaesthetic charts would facilitate identification in the hospital notes for doctors who change hospitals.

The majority (86%) of the charts were A4 size, as recommended by the subcommittee on the standardisation of hospital records;[3] this figure is better than that found in 1976 by Seed and Welsh,[1] but is still not ideal. It would seem obvious that the anaesthetic record chart should contain details of the whole perioperative period. However, the results of our survey showed that only 63% of charts did so; this is a smaller percentage than that in the 1976 study (72%).

Four items of information must be shown clearly on a record chart: name, number, age and ward. Only 36% of the charts contained all four headings, although an additional 27% had a space for an addressograph which may fulfil these requirements. An addressograph is a condensed record of many patient details and may have some advantages, e.g. patient identification and cross checking of blood for transfusion. The patient's name and hospital number have important administrative implications and we were surprised to note that the patient's number was not recorded on all charts. Knowledge of the patient's marital state, religion, occupation and GP's name are not important unless there are special circumstances (e.g. the patient is a Jehovah's Witness). The patient's gender should be obvious from the name though this is not always the case. Other important information such as the date of operation, operation performed, the name of the surgeon and the name of the anaesthetist did not appear on all charts. It may be useful to know the grade of anaesthetist for future reference, for instance in cases of difficult intubation.

No specific space for the pre-operative assessment was found in 27% of charts and in a further 9% the space allowed was less than one line. It may be the practice in these hospitals for the anaesthetist to write the pre-operative assessment in the patient's notes. This certainly allows a full write up and is an important route of communication with the surgeon if the patient is an anaesthetic risk or is unfit for anaesthesia. However, it has the disadvantage that it may be difficult to locate on a future occasion. The most comprehensive format for pre-operative assessment was included in the charts with four sides; an entire side was devoted to the pre-operative findings in three out of the four charts of this type. The use of headings in this space is a useful means of remembering important pieces of information, especially in patients with multisystem disease.

We feel strongly that important information in the pre-operative portion of the chart should include a note on allergies, past anaesthetic history, a chart of dentition, past medical history and duration of fasting. All this information has important clinical and medicolegal implications, but only a minority of the forms included these data. There was a space to write the pre-operative medication on the majority of anaesthetic charts. However, some hospitals insist that it be written on the patient's drug prescription sheet and so duplication may occur. It would seem essential to record both the pre-operative medication dose and its effect on the chart; although most had space to prescribe it only 27% had space to note the effect.

Most (85%) of the charts had a printed grid on which to record readings but the size of this was limited by the quantity of other information on the chart. The use of headings, figures or symbols is a useful additional feature although there is a wide variation in the scales required for charting physiological variables such as arterial pressure, heart rate and central venous pressure. Only a few charts

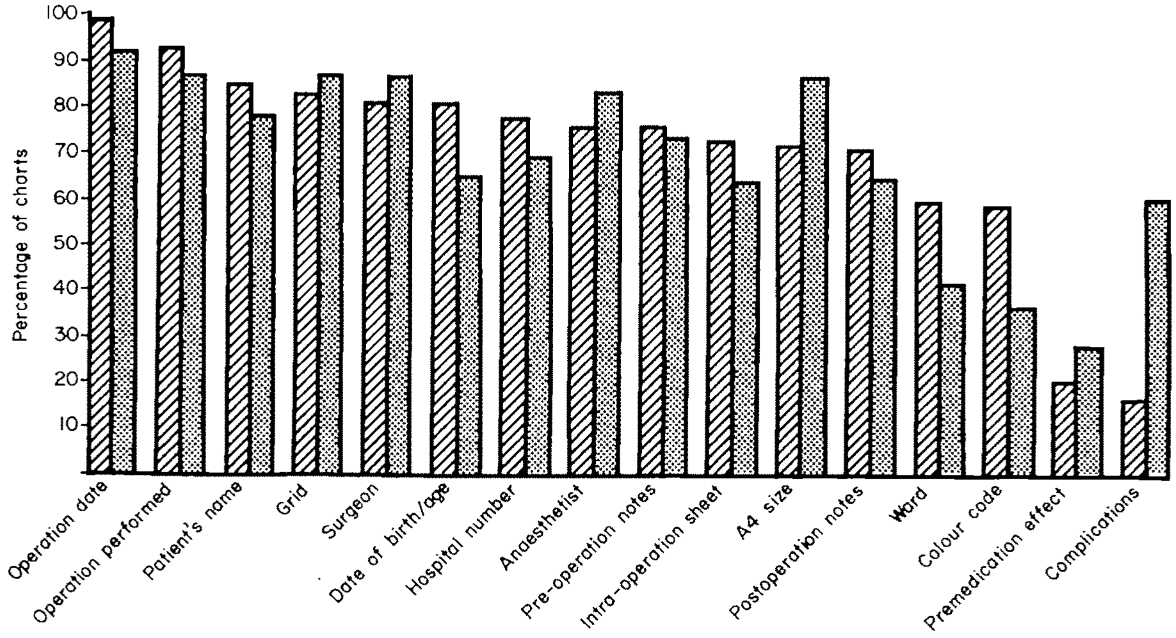

Fig. 1. A comparison of the major findings of the present survey (1987) with those of Seed and Walsh (1976)[1]. ▨, 1976; ░, 1987.

had the facility to record concentrations of oxygen and volatile agents. Several grids had a scale for the respiratory frequency, which seems unnecessary for artificially ventilated patients. The recording of gas flows, volumes delivered by the ventilator, the anaesthetic system used and the concentration and timing of volatile agents are regarded by the Medical Protection Society as essential.[4]

An increasing number of different monitoring and heat conservation devices are used during anaesthesia, but a space to record the type of apparatus used was not included on any of the nonspecialised charts. Many modern monitors produce a printed record which should be attached to the anaesthetic chart.

There has been a marked increase in the number of charts which provide space to record adverse reactions, complications or difficulties. This increased from 16% in 1976 to 59% in our survey and may reflect increased awareness of medicolegal problems in routine clinical practice.

There has been no change in the number of charts with space for postoperative instructions/observations and on many this was still quite inadequate; less than half had space to write postoperative instructions. Specific space to prescribe oxygen occurred as frequently as the position for postoperative nursing. Figure 1 compares the salient points of our survey with those of Seed and Welsh.[1] Almost every chart still falls short of previous recommendations.

Conclusion

Adequate anaesthetic records are important for patient safety, medicolegal reasons and training purposes, and are a requirement of the Faculty of Anaesthetists for the recognition of training posts. Notes may be cramped, incomplete or illegible if charts do not devote sufficient space for pre-operative assessment, peroperative course and postoperative instructions. This may affect future clinical management adversely and may influence the outcome if legal proceedings occur. We believe that a colour coded chart is mandatory as it can be located more readily in the notes before subsequent anaesthetics, and that it is obligatory for the hospital authorities to ensure that anaesthetic records are not mislaid but are incorporated into the patient's notes. The importance of completing anaesthetic record forms cannot be emphasised too strongly. Sechzer[5] noted 'the anesthesia record also reflects the competence of an anesthetist; an illegible, incomplete, unorganised record suggests irresponsibility and a lack of vigilance.' Our review of anaesthetic record charts currently in use in Yorkshire, has demonstrated that there are still deficiencies such as standardisation of size, colour coding, headings for vital patient data and adequate space for pre-operative assessment and postoperative care, but no survey has yet been published which indicates anaesthetists' preferences on the design of their charts.

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References

1. Seed RF, Welsh EA. Anaesthetic records in Great Britain and Ireland. *Anaesthesia* 1976; **31:** 1199–210.
2. Lunn JN, Mushin WW. *Mortality associated with anaesthesia.* Nuffield Provincial Hospitals Trust, London 1982.
3. Standing Medical Advisory Committee. *The Standardisation of Hospital Medical Records.* London: Her Majesty's Stationery Office, 1965.
4. Medical Protection Society. *Annual Report and Accounts,* 1986.
5. Sechzer PH. Anesthesia documentation and evaluation. *Quality Review Bulletin* 1981; **7:** 28–34.

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Premedication with oral slow release morphine in dental anaesthesia. A comparison with temazepam

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Summary

Oral slow release morphine 30 mg and temazepam 30 mg given as premedication 2 hours before operation were compared in 62 patients who underwent extraction of four third molar teeth in a randomised double-blind trial. There was no significant difference in pre-operative sedation; the majority were mildly or moderately sedated. Patients in the morphine group woke up significantly faster and had significantly reduced requirements for analgesics after operation.

Key words

Analgesics, narcotic; morphine.
Hypnotics, benzodiazepines; temazepam.

Oral premedication is easy to administer and more acceptable to patients than intramuscular administration. Benzodiazepines and opioids are used commonly by this route for premedication. The anxiolytic effects of the opioids are mild, but their sedative properties make them popular and the analgesia produced contributes to a balanced anaesthetic regimen.[1] Oral slow release morphine (MST) produces a sustained plasma concentration of morphine when given in a single dose[2] and causes more sedation than when given in an equivalent dose intramuscularly.[3] However, because absorption is slow it must be started well in advance of surgery.[4]

This study was designed to compare and contrast two oral premedicants, temazepam and MST, in patients who underwent dental surgery. The possible analgesic effects in the postoperative period were also studied.

Method

Sixty-two patients who underwent extraction of impacted four third molar teeth were studied, after ethics committee approval and informed consent. The patients were aged 16–60 years, ASA grade 1 or 2, and none was taking analgesic, anxiolytic, or sedative medication. The patients were shown their personal pain analogue score sheets on the day before surgery and asked to quantify their pain at 2, 6 and 12 hours after operation. They were also requested to communicate any unpleasant side effects of the procedure.

The patients were allocated randomly to two groups to receive either temazepam 30 mg or MST 30 mg orally 2 hours before surgery. The patient, anaesthetist, and ward sister were unaware of the treatment. The degree of sedation in the anaesthetic room was assessed by the same anaesthetist on all occasions, and was categorised into one of four groups: 0, wide awake; 1, mildly sedated, drowsy but not sleeping; 2, moderately sedated, sleeping on arrival in the anaesthetic room but waking spontaneously; 3, very sedated, sleeping but waking only in response to command.

Anaesthesia was induced with thiopentone 3–5 mg/kg and intubation of the trachea with a cuffed, red rubber, nasotracheal tube was facilitated by suxamethonium 1 mg/kg. A moist pack was positioned in the oropharynx. The patient breathed spontaneously through a Bain coaxial breathing system with a fresh gas flow of at least 150 ml/kg/minute. Anaesthesia was maintained with nitrous oxide 67% and halothane 1–2% in oxygen. Arterial pressure, ECG, and end tidal carbon dioxide were monitored throughout surgery. The latter was recorded on a printer and the maximum value noted.

The patients were turned into the left lateral position at the end of the operation, with a head down tilt whilst still anaesthetised and the trachea extubated. The wake up time was defined as from the end of volatile anaesthetic to the correct response to three simple commands; to open their eyes, to protrude their tongue and to state their name. Papaveretum 0.2 mg/kg intramuscularly or paracetamol 1 g orally were prescribed for all patients, given at the ward sister's discretion depending on the degree of postoperative pain. The patients were reviewed at 2, 6 and 12 hours after operation by the anaesthetist who administered the anaesthetic. They were asked to record the severity of pain on a 10-cm analogue scale, which ranged from zero for no pain at all, to 10 for the worst pain imaginable.

Statistical methods. Demographic data are shown as mean (SEM). Qualitative response variables, pre-operative sedation, requirement for analgesia and postoperative nausea were assessed with a Chi-squared test for 2 × 2 contingency tables. A Mann–Whitney *U* test showed significant difference in the wake up time between the two groups and in the maximum end tidal CO_2 level.

Results

There were no significant differences between the two groups with respect to sex, age and weight (Table 1) or in the degree of sedation before surgery; the majority were mildly or moderately sedated (Table 2). None of the patients appeared to be wide awake and only three appeared very sedated, two who received temazepam. The maximum end tidal CO_2 concentration in the temazepam group

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Table 1. Demographic data.

	Males: females	Age, years, (SEM)	Weight kg, (SEM)
MST	25:6	24.4 (0.70)	73.1 (1.80)
Temazepam	20:11	26.5 (0.80)	73.8 (2.16)
p value	NS	NS	NS

Table 2. Pre-operative sedation. Numbers in each group.

	Wide awake	Mild sedation	Moderate sedation	Very sedated
MST	0	17	13	1
Temazepam	0	14	15	2
p value		NS		

Table 3. Pain scores of patients who received no analgesia.

	2 hours	6 hours
MST		
no analgesia	23/31	20/31
mean	3.2	1.6
range	0–8	0–6
Temazepam		
no analgesia	16/31	7/31
mean	4.0	2.5
range	0–6	0–7

(5.4%, SEM 0.1), did not differ significantly from those who received MST (5.5%, SEM 0.1). The patients in the MST group had a mean wake up time of 10 minutes compared to 13 minutes in the temazepam group, which was statistically significant at the 1% level (Fig. 1).

The pain scores in patients who received no postoperative analgesia were noted to be less at both 2 and 6 hours in the MST group, but this difference was not significant (Table 3). Nor was there any significant difference between those who felt nauseated postoperatively in the two groups. Five patients given temazepam complained of nausea compared to eight in the MST group at 2 hours after operation; none of them had received papaveretum for postoperative pain. The number of patients in the MST group, at both 6 and 12 hours, who required postoperative analgesia was significantly lower than the temazepam group. Administration of paracetamol was not significantly different between the two groups, although papaveretum administration was significantly higher in the temazepam group. (Table 4).

Table 4. Postoperative analgesia administration.

	MST ($n = 31$)	Temazepam ($n = 31$)	p value
6 hours			
Papaveretum	6	14	$p < 0.05$
Paracetamol	5	10	NS
Total	11	24	$p < 0.01$
12 hours			
Papaveretum	6	14	$p < 0.05$
Paracetamol	10	12	NS
Total	16	26	$p < 0.01$

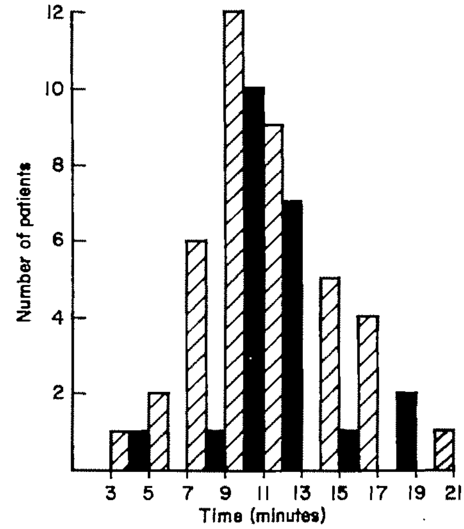

Fig. 1. Wake up times. ▨, MST (mean 10.35 minutes), ■, temazepam (mean 13.00 minutes).

Discussion

Oral slow release morphine offers considerable advantages as a premedicant for patients who experience removal of four third molar teeth; it is easy to administer, acceptable to patients, and is an effective sedative when given 2 hours pre-operatively. It was associated with a quicker wake up time than temazepam and patients who received MST pre-operatively needed significantly less analgesia after operation.

Anxiolysis and sedation are recognised to be different entities; opioids provide more sedation than anxiolysis.[1] Objective assessment of patients in the anaesthetic room failed to show any significant difference between our two groups; the majority were either mildly or moderately sedated. MST has been shown to be slowly but well absorbed with a relatively long duration of action of 6 to 12 hours,[5] which may be a useful property in a premedicant and help to overcome the unpredictability of operating lists.[4] Prolonged sedation postoperatively, especially in patients who are likely to have blood in the mouth and pharynx, increases the risk of inhalation. Patients in the MST group woke up significantly faster, which may reduce this risk. It is known that opioid analgesics are a major cause of delayed gastric emptying in the pre-operative period,[6] and whereas intramuscular morphine may cause a considerable reduction[4] MST has little effect on this function. No patient complained of untoward effect from their anaesthetic and neither group appeared significantly more nauseated.

Relief of postoperative pain is frequently unsatisfactory, despite attempts to use new analgesic drugs and new administration techniques. Patients may experience marked pain especially in the first 12 hours[7] after dental surgery and Hanks *et al.*[8] concluded the MST was not suitable for the treatment of such pain. However, because of the length of time it takes to reach its peak plasma concentration,[4] if it is to be used to treat postoperative dental pain, it must be started well in advance and this may explain the previous poor results. In our study at both 6 and 12 hours, the administration of postoperative analgesia was significantly reduced in the MST group. This underlines the benefit of the long duration of action which is attributed to MST.

References

1. Pinnock CA, Derbyshire DR, Elling AE, Smith G. Comparison of oral slow release morphine (MST) with intramuscular morphine for premedication. *Anaesthesia* 1985; **40:** 1082–5.
2. Hanks GW, Twycross RG, Bliss JM. Controlled release morphine tablets: a double blind trial in patients with advanced cancer. *Anaesthesia* 1987; **42:** 840–4.

3. Fell D, Chmielewski A, Smith G. Postoperative analgesia with controlled release morphine sulphate: comparison with intramuscular morphine. *British Medical Journal* 1982; **285:** 92–4.
4. Park GR, Weir D. A comparison of the effect of oral controlled release morphine and intramuscular morphine on gastric emptying. *Anaesthesia* 1984; **39:** 645–8.
5. Derbyshire DR, Vater M, Maile CID, Larsson M, Aitkenhead AR, Smith G. Non-parenteral postoperative analgesia. A comparison of sublingual buprenorphine and morphine sulphate (slow release) tablets. *Anaesthesia* 1984; **39:** 324–8.
6. Nimmo WS. Effect of anaesthesia on gastric motility and emptying. *British Journal of Anaesthesia* 1984; **56:** 29–36.
7. Seymour RA, Blair GS, Wyatt FAR. Part 1. Postoperative dental pain and analgesia efficacy. *British Journal of Oral Surgery* 1983; **21:** 290–7.
8. Hanks GW, Rose NM, Aherne GW, Piall EM, Fairfield S, Trueman T. Controlled release morphine tablets. A double-blind trial in dental surgery patients. *British Journal of Anaesthesia* 1980; **53:** 1259–63.

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Comparison between propofol and thiopentone for induction of anaesthesia in children

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Summary

Propofol 2.5 mg/kg was compared with thiopentone 5 mg/kg in a randomised open study, as an induction agent in paediatric anaesthesia. One hundred and twenty children who were to undergo elective surgery were included in the study. Both propofol and thiopentone produced a rapid and smooth induction with a low incidence of side effects. A similar decrease (10%) in mean arterial pressure was observed with both agents, but propofol showed better suppression of the haemodynamic response to tracheal intubation. Respiratory upsets occurred less frequently with propofol than with thiopentone, but propofol frequently induced discomfort on injection. Both agents provided satisfactory and controllable induction of anaesthesia and no major adverse reactions occurred during or after anaesthesia. We conclude that propofol is a useful alternative as an induction agent in children.

Key words

Anaesthetics, intravenous; thiopentone, propofol.
Anaesthesia; paediatric.

The first clinical use of propofol was described by Kay and Rolly in 1977.[1] Its original Cremophor EL formulation was associated with a significant risk of anaphylactoid reactions[2] and a high incidence of pain on injection,[3] and it was recently reformulated in an aqueous emulsion.[4] Initial animal studies showed anaesthetic properties similar to those of the original formulation.[4] Clinical trials in man have shown the new formulation to have many promising features, which include a smooth induction of anaesthesia,[5] a low incidence of side effects[6] and rapid recovery.[7,8]

The usefulness of propofol has been studied principally in adults and has not been evaluated thoroughly as an induction agent in children. We therefore designed a study to compare the anaesthetic properties of the new formulation of propofol with those of thiopentone for the induction of anaesthesia in children.

Method

One hundred and twenty children (ASA class 1–2) who were to undergo elective surgery were included in the study, after approval by the Hospital Ethics Committee. Patients were assigned randomly to receive either propofol or thiopentone for induction of anaesthesia. They were then allocated to one of three groups depending on their age: group 1, 1–3 years; group 2, 4–7 years; group 3, 8–16 years. Patient characteristics are given in Table 1.

Premedication consisted of flunitrazepam 0.02–0.03 mg/kg orally, and EMLA emulsion cream was used to anaesthetise the skin at least one hour before venous cannulation and induction of anaesthesia. Anaesthesia was induced either with propofol 2.5 mg/kg or thiopentone 5 mg/kg followed by atropine 0.01 mg/kg. The injection of the induction agent was given over 30 seconds into a vein on the back of the hand. Supplementary doses of the induction agent (propofol 0.5 mg/kg, thiopentone 1 mg/kg) were given if the initial dose failed to induce unconsciousness. Suxamethonium 2 mg/kg was used to facilitate tracheal intubation. Anaesthesia was maintained with 70% nitrous oxide in oxygen, pancuronium 0.1–0.3 mg/kg was used for muscle relaxation and fentanyl 3 μg/kg for analgesia. Occasionally anaesthesia was also supplemented with isoflurane (0.5–1.0%). Atropine 0.02 mg/kg and neostigmine 0.05 mg/kg were used to reverse the neuromuscular block. Postoperative analgesia (a paracetamol 10 mg/kg suppository, or pethidine 1 mg/kg intravenously or

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Table 1. Patient characteristics, mean (SD).

	Group 1		Group 2		Group 3	
	Propofol (n = 20)	Thiopentone (n = 20)	Propofol (n = 20)	Thiopentone (n = 20)	Propofol (n = 20)	Thiopentone (n = 20)
Age, years	2.44 (0.95)	2.27 (0.27)	5.63 (1.14)	5.69 (1.17)	11.8 (2.49)	12.2 (2.36)
Weight, kg	14.4 (3.3)	13.3 (2.3)	21.5 (3.8)	22.3 (4.6)	38.0 (9.7)	42.1 (11.7)
Height, cm	91.0 (10.1)	91.0 (8.3)	116.1 (7.29)	117.2 (7.29)	148.3 (14.7)	150.8 (9.82)
Males: females	15:5	19:1	8:12	14:6	10:10	11:9
ASA classes 1 and 2	18:2	18:2	19:1	17:3	17:3	17:3

intramuscularly), was given if required in the recovery room.

Tests were carried out after the start of the induction agent injection to determine whether consciousness was lost (the patient did not respond to command), whether a facemask was tolerated and whether the eyelash reflex had disappeared. The induction time was taken as the time from the start of the injection to abolition of the eyelash reflex. Apnoea was defined as the absence of spontaneous respiration for a period of 20 seconds or more. Ventilation was assisted if apnoea lasted for more than one minute.

Systolic and diastolic arterial pressures and heart rate were measured indirectly with a Dinamap (Criticon, USA) before (baseline) induction of anaesthesia, after insertion of the cannula, immediately after injection of the induction agent, after tracheal intubation and thereafter at 5-minute intervals throughout the anaesthesia. The ECG was displayed continuously. The occurrence of any discomfort on injection of the induction agent (spontaneous complaint, movements related to pain on injection, crying) was recorded. The presence of any other side effects (movement, twitching, tremor, masseter spasm, hiccup, hypertonia, cough, bronchospasm, laryngospasm, flush, rash, restlessness) at induction or during maintenance of anaesthesia was noted. The end tidal carbon dioxide ($P\text{E}'\text{CO}_2$) was monitored continuously by a Normocap CO_2-analyser (Datex, Helsinki) and the ventilatory parameters adjusted to maintain the $P\text{E}'\text{CO}_2$ at 4.7–6.0 kPa. Body temperature was monitored throughout the anaesthesia and maintained at a normal range.

The time intervals from the end of the operative procedure until the patients opened their eyes on command and until they were orientated (age over 4 years) were recorded during recovery. The duration of surgery was noted. Postoperative amnesia was tested by showing two pictures before operation (age over 4 years), selected from the following four: car, shoe, flower and horse. The ability of the children to recall the pictures shown was recorded as they left the recovery room. The presence of any side effects, such as cough, bronchospasm, laryngospasm, flush, rash, headache, nausea, vomiting, elation, euphoria, depression, crying, confusion, restlessness, venous phlebitis/thrombosis during the recovery period was noted. The completeness of recovery was assessed in the recovery room at 10-minute intervals (up to 70 minutes from tracheal extubation) with a scoring system which measured conscious level, respiration, colour, heart rate, movements, restlessness and crying, each giving scores from 0 to 2. The maximum total attainable score was 14. The administration of any postoperative analgesic drugs was recorded. The anaesthetists assessed the quality of induction and maintenance of anaesthesia as good, adequate or poor.

Mean arterial pressure (MAP) was calculated as 1/3 × (SAP + 2 × DAP) and rate pressure product (RPP) as SAP × HR. Data are presented as mean values (standard deviation, SD). The statistical analysis of the haemodynamic data was carried out with two-way Anova with repeated measures on two factors.[9] The differences between the groups were compared with Student's t-test for parametric data and the Chi-squared test for nonparametric data.

Results

The three study groups were comparable for age, weight, height, sex and ASA class (Table 1). The onset of anaesthesia was rapid (< 45 seconds) both with propofol and with thiopentone, and no supplementary doses of the induction agents were needed. Apnoea occurred more frequently with older children, but neither the incidence nor the duration of apnoea differed between propofol and thiopentone groups (Table 2). The incidence of side effects was similar after both drugs (Table 3). Respiratory upset (hiccup, cough, laryngospasm) during induction occurred more frequently with thiopentone (23%) than with propofol (3%). With propofol 28% of the patients recalled discomfort on injection in contrast to none with thiopentone.

The results for haemodynamic variables are presented in Fig. 1. Both propofol and thiopentone caused a similar decrease (10%) in mean arterial pressure after induction of anaesthesia. Heart rates were stable or deviated from the baseline values by roughly 5–10% with both agents. The increase in mean arterial pressure after intubation was greater with thiopentone than with propofol (24% vs 16%). The heart rate (14% vs 10%) and rate pressure product (32% vs 18%) increased more with thiopentone than with propofol after intubation (Fig. 1). The anaesthetists graded the quality of induction as good in 82% of patients induced with propofol and in 72% of patients induced with thiopentone (Table 3).

The duration of the operative procedure and the recovery times from the end of surgery until the patients opened their eyes on command were similar in both the propofol

Table 2. Induction time, mean (SD), incidence and duration of apnoea, mean (SD) in each group.

	Group 1		Group 2		Group 3	
	Propofol (n = 20)	Thiopentone (n = 20)	Propofol (n = 20)	Thiopentone (n = 20)	Propofol (n = 20)	Thiopentone (n = 20)
Induction time, seconds	44.0 (9.4)	41.8 (3.4)	39.6 (8.0)	41.0 (4.5)	43.2 (6.5)	44.7 (10.7)
Apnoea over 20 seconds, n	4	1	10	10	15	13
Duration of apnoea, seconds	47.5 (5.0)	50.0	44.0 (8.4)	46.5 (6.7)	46.0 (6.3)	45.3 (5.2)

Table 3. Numbers of patients with side effects during induction, and assessment of the quality of induction in each group.

	Group 1		Group 2		Group 3	
	Propofol ($n = 20$)	Thiopentone ($n = 20$)	Propofol ($n = 20$)	Thiopentone ($n = 20$)	Propofol ($n = 20$)	Thiopentone ($n = 20$)
Side effects						
Discomfort on injection	7	0	4	0	6	0
Spontaneous movements	3	3	4	0	0	0
Hiccup	0	2	0	4	0	2
Cough	0	4	1	1	1	0
Laryngospasm/bronchospasm	0	0	0	1	0	0
Flush/rash	0	1	0	0	0	2
Crying/restlessness	4	3	0	1	3	2
ECG changes	0	0	0	1	0	1
Total	14	13	9	8	10	7
Assessment by anaesthetists						
Good	16	13	17	14	16	16
Adequate	4	6	3	4	4	4
Poor	0	1	0	2	0	0

Table 4. Duration of surgery and recovery time from the end of surgery to opening of eyes on command, mean, (SD).

	Group 1		Group 2		Group 3	
	Propofol ($n = 20$)	Thiopentone ($n = 20$)	Propofol ($n = 20$)	Thiopentone ($n = 20$)	Propofol ($n = 20$)	Thiopentone ($n = 20$)
Duration of surgery, minutes	52.8 (59.4)	39.7 (21.6)	44.4 (56.5)	28.2 (23.4)	49.2 (46.9)	33.8 (23.8)
Recovery time, minutes	8.4 (5.4)	9.3 (6.1)	9.7 (7.8)	14.9 (13.7)	8.9 (6.2)	11.6 (9.1)

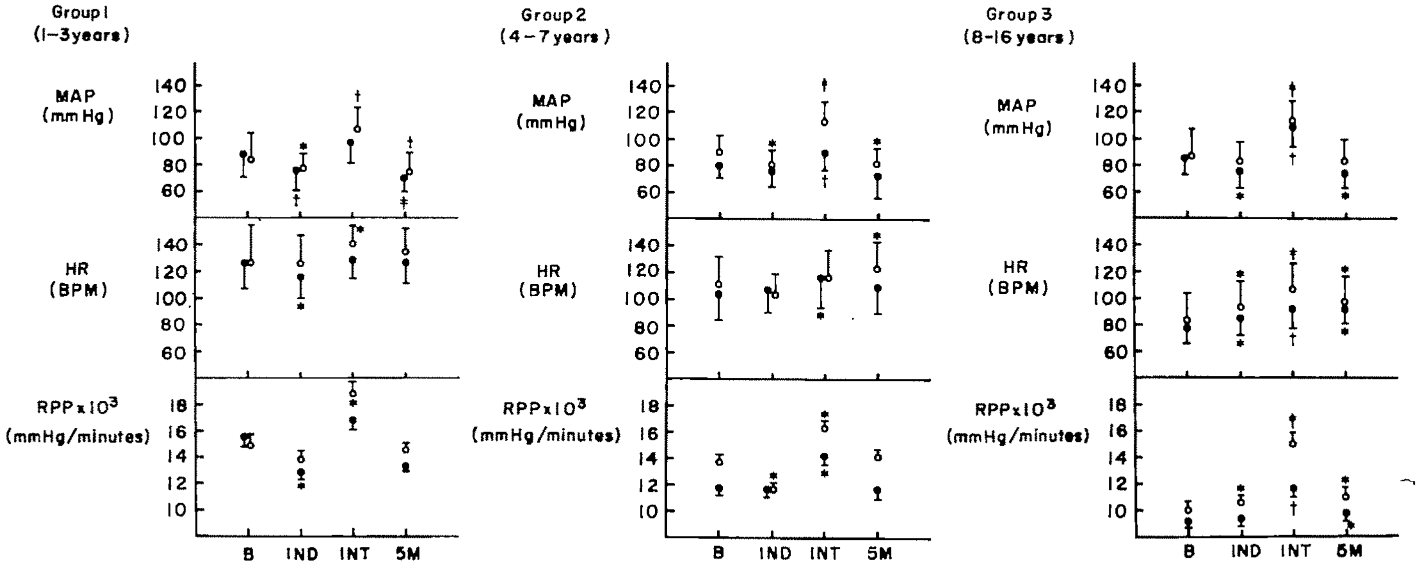

Fig. 1. Mean arterial pressure (MAP), heart rate (HR) and rate pressure product (RPP) before induction of anaesthesia (B), immediately after injection of the induction agent (IND), immediately after intubation (INT) and 5 minutes after the induction of anaesthesia with propofol (●) and thiopentone (○) in group 1, 1–3 years; group 2, 4–7 years; and group 3, 8–16 years. Mean (SD) repeated measures Anova. * $p < 0.05$; † $p < 0.01$; ‡ $p < 0.001$; compared with baseline value, B.

and thiopentone groups (Table 4). The need for supplementary isoflurane was similar. The amount of postoperative analgesia, the recovery room scores and the side effects during recovery (Table 5) did not differ between the induction agents. The pictures shown before operation were recalled by all patients. No major adverse reactions occurred either during or after anaesthesia.

Discussion

At present the alternatives available for intravenous induction of anaesthesia are few. Thiopentone, which is most often the drug of choice for this purpose, has some undesirable features: it is unstable in aqueous solution and an irritant on extravenous injection; its elimination half-life is fairly long (6–10 hours) and it can cause marked decreases in arterial pressure. Other alternatives also have their disadvantages. Methohexitone is associated with a high incidence of excitatory side effects.[10] Althesin and propanidid have been withdrawn because of allergic reactions[11] and etomidate suppresses cortisol synthesis.[12] Benzodiazepines are also unreliable as routine induction agents;[13] both flunitrazepam[14] and midazolam[15] have proved to be unsatisfactory agents for induction of anaesthesia in children.

No previous reports on the use of propofol for anaes-

Table 5. Numbers of patients with side effects during recovery in each group.

	Group 1		Group 2		Group 3	
	Propofol (n = 20)	Thiopentone (n = 20)	Propofol (n = 20)	Thiopentone (n = 20)	Propofol (n = 20)	Thiopentone (n = 20)
Side effects						
Cough	0	3	3	3	2	5
Laryngospasm	0	2	1	1	0	2
Flush/rash	2	1	1	1	0	1
Nausea/vomiting	2	3	2	5	5	5
Depression/crying	2	1	1	4	0	1
Confusion/restlessness	1	0	2	2	1	1
Venous phlebitis/thrombosis	0	0	0	0	0	1
Total	7	10	10	16	8	16

thesia in children under the age of 8 years have been found in the literature. Propofol in our study produced rapid and smooth induction with a low incidence of side effects. Respiratory upsets were very rare with propofol in contrast to thiopentone. This may be because propofol does not induce histamine release.[16] However, pain on injection into small veins on the dorsum of the hand remained a problem. It is suggested that if veins in the forearm or in the antecubital fossa are used[17] or if lignocaine is mixed with propofol,[18,19] the incidence of pain can be reduced to an acceptable level.

Our results show only a slight decrease of similar magnitude in mean arterial pressure with both propofol and thiopentone. However, earlier studies in adults[5,8,19] have reported more arterial hypotension with propofol than with thiopentone; the present finding with children therefore needs further evaluation. The haemodynamic response to laryngoscopy and intubation was suppressed significantly better by propofol compared with thiopentone. This supports the finding reported by Glen[20] that in mice propofol produced more depression of nociceptive reflex responses than did thiopentone.

The quality of maintenance and recovery from anaesthesia was similar in all groups, and this probably reflects the standard premedication (flunitrazepam) and anaesthesia technique used. We conclude that propofol appears to be a useful alternative as an induction agent in paediatric anaesthesia.

Acknowledgments

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References

1. Kay B, Rolly C. I.C.I. 35868, a new intravenous induction agent. *Acta Anaesthesica Belgica* 1977; **28:** 303–16.
2. Briggs LP, Clarke RSJ, Watkins J. An adverse reaction to the administration of disopropofol (Diprivan). *Anaesthesia* 1982; **37:** 1099–101.
3. Briggs LP, Clarke RSJ, Dundee JW, Moore J, Bahar M, Wright PJ. Use of di-isopropyl phenol as main agent for short procedures. *British Journal of Anaesthesia* 1981; **53:** 1197–201.
4. Glen JB, Hunter SC. Pharmacology of an emulsion formulation of I.C.I. 35868. *British Journal of Anaesthesia* 1984; **56:** 617–25.
5. Mackenzie N, Grant IS. Comparison of propofol with methohexitone in the provision of anaesthesia for surgery under regional blockade. *British Journal of Anaesthesia* 1985; **57:** 1167–72.
6. Nightingale P, Healy TEJ, Hargreaves J, McGuinness K, Kay B. Propofol in emulsion form: induction characteristics and venous sequelae. *European Journal of Anaesthesiology* 1985; **2:** 361–8.
7. Rolly G, Versichelen L. Comparison of propofol and thiopentone for induction of anaesthesia in premedicated patients. *Anaesthesia* 1985; **40:** 945–8.
8. Walmsley AJ, McLeod B, Ponte J. The new formulation of I.C.I. 35868 (propofol) as the main agent for minor surgical procedures. *European Journal of Anaesthesiology* 1986; **3:** 19–26.
9. Cohen L, Holliday M. *Statistics for social scientists.* London: Harper and Row, 1982.
10. Dundee JW. Intravenous anaesthesia and the need for new agents. *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 3–6.
11. Dundee JW. New i.v. anaesthetics. *British Journal of Anaesthesia* 1979; **51:** 641–8.
12. Wanscher M, Tonnesen E, Huttel M, Larsen K. Etomidate infusion and adrenocortical function. A study in elective surgery. *Acta Anaesthesiologica Scandinavica* 1985; **29:** 483–5.
13. Kanto J, Klotz W. Intravenous benzodiazepines as anaesthetic agents: pharmacokinetics and clinical consequences. *Acta Anaesthesiologica Scandinavica* 1982; **26:** 554–69.
14. Iisalo E, Kanto J, Aaltonen L, Mäkelä J. Flunitrazepam as an induction agent in chlidren. A clinical and pharmacokinetic study. *British Journal of Anaesthesia* 1984; **56:** 899–902.
15. Salonen M, Kanto J, Iisalo E. Induction of general anaesthesia in children with midazolam: is there an induction dose? *International Journal of Pharmacology, Therapy, and Toxicology* 1987; **25:** 613–5.
16. Doenicke A, Lorenz W, Stanworth D, Duka T, Glen JB. Effects of propofol ('dipravan') on histamine release, immunoglobulin levels and activation of complement in healthy volunteers. *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 15–20.
17. Wells JKG. Comparison of I.C.I. 35868, etomidate and metohexitone for day-case anaesthesia. *British Journal of Anaesthesia* 1985; **57:** 732–35.
18. Brooker J, Hull CJ, Stafford M. Effect of lignocaine on pain caused by propofol injection. *Anaesthesia* 1985; **40:** 91–2.
19. Redfern N, Stafford MA, Hull CJ. Incremental propofol for short procedures. *British Journal of Anaesthesia* 1985; **57:** 1178–82.
20. Glen JB. The animal pharmacology of I.C.I. 35868: a new i.v. anaesthetic agent. *British Journal of Anaesthesia* 1980; **52:** 230.

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The Oxford Miniature Vaporizer in paediatric anaesthesia.
An experimental study

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Summary

An experimental study of the Oxford Miniature Vaporizer in combination with a paediatric resuscitation bag has demonstrated efficient halothane vaporization at small tidal volumes. This technique will be appropriate in paediatric anaesthesia with the Triservice apparatus.

Key words

Anaesthetics volatile; halothane.
Equipment; vaporizers.

The Oxford Miniature Vaporizer (OMV) is a simple drawover vaporizer which can be used with a variety of volatile anaesthetic agents and forms an integral part of the Triservice anaesthetic apparatus.[1,2] Its performance with the low flows encountered in paediatric anaesthesia has been noted to be variable; the output decreases at small minute volumes, especially when it is used in a continuous flow mode.[3]

The manufacturers recommend that the Triservice system should be connected in such a way as to form a T-piece system[1] (Fig. 1) when the OMV is used in paediatric anaesthesia. However there are reports that both the EMO[4] and the OMV[5] are used in conjunction with the Ambu Paedivalve and a paediatric resuscitation bag. The concentration of halothane produced under these circumstances is uncertain and an experiment was designed to determine halothane concentrations produced by the vaporizer in the drawover mode.

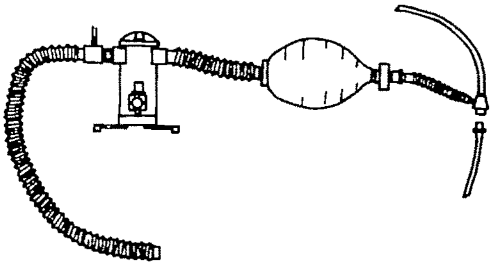

Fig. 1. Recommended Triservice system for paediatric anaesthesia.

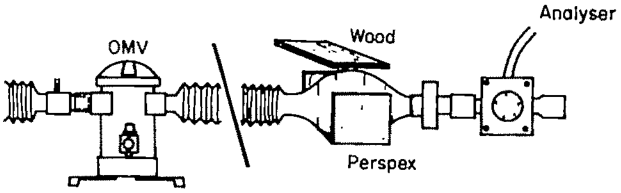

Fig. 2. Experimental apparatus.

Method

A new OMV 50 vaporizer was used in the experiment and the calibration was checked as recommended[6] by the manufacturers. Three experiments were carried out.

Resuscitation bag flow rates. Peak flow rates and the mean flows generated by an adult and a paediatric Laerdal resuscitation bag during the filling phase were measured with a Timetec RT 200 calibration analyser. The additional port for adding oxygen to the bags was occluded during the experiments.

Halothane output from an OMV 50 at paediatric and adult tidal volumes in the drawover mode. The design of the experiment is shown in Fig. 2. The tidal volume was controlled by placing the resuscitation bag on a U-shaped piece of perspex; a piece of wood 5.08 by 25.4 cm was pressed down on it until contact was made with the sides of the perspex. Compression of the resuscitation bag was controlled by use of different pieces of perspex with varying side heights. The tidal volumes produced were measured with a Timetec RT 200 analyser and were reproducible to within 10% of the desired volume. The vaporizer was filled with halothane at room temperature, and the ambient temperature and the temperature of the halothane in the vaporizer recorded. The resuscitation bags were compressed 30 times per minute at the following tidal volumes: paediatric bag 50, 100, 150 ml; adult bag 150, 200, 300, 400, 500 ml.

At the outset of the experiment, the first tidal volume was selected, and the vaporizer was set at 1 on the halothane scale. The concentration delivered was measured by an Engström Emma vapour analyser when the reading had stabilised. Halothane concentrations were measured after this with the vaporizer lever set on positions 2, 3 and 4; the resultant halothane concentrations were noted before moving to the next tidal volume. This process was repeated

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at all tidal volumes, after which the vaporizer temperature was measured again. The vaporizer was allowed to warm fully to room temperature after each series of measurements.

The direction of the experiment after four series was repeated in reverse, since a considerable decrease in the vaporizer halothane temperature occurred during each series of measurements. The first four experiments were therefore in ascending order of tidal volumes; they started at 50 ml and finished at 500 ml. This direction of experiment was termed forward. The second four experiments were carried out in the reverse order of tidal volume; this direction was termed backwards. It was found that for the duration of an experiment (around 20 minutes) the vaporizer did not require to be refilled.

Halothane output and vaporizer temperature change. These were measured at the start and at the end of a period of one hour of ventilation at a frequency of 30/minute at a tidal volume of 60 ml and with the OMV set at halothane mark 3.

Statistical analysis for experiment 1 was performed with a paired *t*-test. Data from experiment 2 are presented as the range of results obtained during the experiments.

Results

The paediatric resuscitation bag generated a greater filling flow rate than the adult bag (Table 1). Halothane concentrations from the OMV 50 are shown in Fig. 3. The effect of temperature on the output of the OMV is clear; vaporizer temperature decreased considerably during the course of each experiment. The mean starting temperature was 20.6°C (SD 2.2), mean finishing temperature 17°C (2.4) and the mean decrease in temperature 3.6°C (0.6). Vaporization at all tidal volumes was efficient but the spread of results was greatest at higher concentrations of halothane, and at the smallest and largest tidal volumes. The most reproducible results were at medium tidal volumes. The starting temperature was 21.5°C, and the finishing temperature 19.1°C during the one-hour study. The halothane output was 2.5% at the start and 2% at the end.

Table 1. Resuscitation bag inflation phase flow rates (litres/minute). Values are presented as mean (SD).

	Adult bag	Paediatric bag
Peak flow	46.6 (0.9)	52.5 (4.0)*
Mean flow	15.7 (1.3)	18.7 (1.5)*

* $p<0.05$ adult bag v paediatric bag.

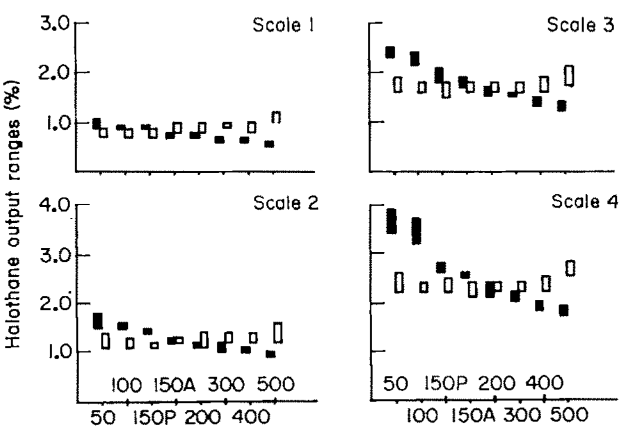

Fig. 3. Halothane concentrations (%) delivered by OMV 50 using a paediatric resuscitation bag at tidal volumes of 50, 100 and 150 ml, and an adult resuscitation bag at 150, 200, 300, 400 and 500 ml. ■, forwards; □, backwards; P, paediatric bag; A, adult bag.

Discussion

Drawover anaesthesia is practised widely and is easier to apply in adults than in children. It is recommended that both the EMO and OMV apparatus are converted to form T-pieces during paediatric anaesthesia; the EMO is suitable for use with a Farman's entrainer,[7] but the OMV should be used as shown in Fig. 1.[1] Use of the OMV in this way is inconvenient to the single-handed anaesthetist (a common situation overseas), especially during intermittent positive pressure ventilation, and the technique would be simplified if it were possible to use a simple drawover method as in an adult.

The results in Fig. 3 show that there is efficient vaporization at small tidal volumes when a paediatric resuscitation bag is used in a drawover mode with the OMV. Previous work has shown that the output of the OMV vaporizer decreases at low minute volumes, especially when used in the continuous flow mode.[3] The minute volume across the vaporizer was low at paediatric tidal volumes in our study, but the actual flow generated across the vaporizer during the filling phase of the resuscitation bag was considerably higher than simple measurement of the minute volume would suggest. This efficient vaporization at small tidal volumes (and low minute volumes) may be related to these high flows, which may cause more efficient vaporization within the vaporizer. The marked decrease in output when used in a plenum mode[3] at minute volumes less than 3 litres is likely to be related to the very low flow across the vaporizer.

A rapid respiratory rate was chosen in our study both to simulate paediatric ventilation, and also to cause sufficient cooling within the vaporizer to permit the effects of temperature to be established. The mean decrease in temperature over the course of a series of measurements was 3.6°C, and the halothane output was affected more by temperature than by tidal volume. The reason that the output from the vaporizer was most stable in the middle range of tidal volumes is probably because of the smaller variation in temperature at the midpoint of both sets of experiments. It is also important to note that the OMV was designed to produce the most consistent outputs over medium values of tidal volume (A.C. Green personal communication). Outputs from the vaporizer varied most at the extremes of tidal volume, where the changes in temperature were greatest. On the fourth mark on the halothane scale, the variation of halothane output with tidal volume was less during the backward series than during the forward series. The reason for this is that the majority of the cooling effect was taking place at the large tidal volumes, and resulted in early cooling of the vaporizer during the backward experiments. This resulted in a more stable temperature during the remainder of the experiment compared with the forward experiment, when cooling progressed more gradually. The decrease in output from our vaporizer at low temperatures was rather greater than that measured by Houghton.[2]

Data from the prolonged experiment carried out over a period of one hour demonstrates that, in clinical practice at paediatric tidal volumes, less cooling of the vaporizer should occur. This indicates that the data in Fig. 3 probably represent the widest range of measurements which would be encountered during drawover anaesthesia. Output should remain relatively stable, provided that the vaporizer is kept topped up with halothane at room temperature. A similar set of experiments on an OMV 30 revealed similar performance characteristics to the OMV 50, with efficient vaporization at small tidal volumes; in addition, a more rapid cooling effect at large tidal volumes occurred, probably because of the smaller amount of halothane in the vaporizer.

Vaporizer output is also affected by the type of connecting tubing used between vaporizer and patient. Different tubing may result in absorption of between 5% and 16% of halothane from the vaporizer[3] and this factor may become important at higher concentrations. Our experiment used 75 cm of polyvinyl chloride connecting tubing between the vaporizer and the analyser, and this arrangement has been shown to cause absorption of less than 10%.

It is clear from our study that the output from the OMV with a paediatric resuscitation bag is as efficient as the technique recommended by Penlon.[1] Outputs of halothane are less stable at higher settings on the vaporizer, but this is unlikely to be a problem during paediatric anaesthesia. Small children probably require assisted or controlled ventilation to avoid problems from the added resistance of a drawover technique.[1] Vaporizer cooling will be a greater problem if the Penlon technique is used, as a relatively high minute volume must be provided to supply gas to a T-piece arrangement. It is our impression that adequate halothane vaporization for paediatric anaesthesia is produced by this technique with the Triservice apparatus.

Acknowledgments

The authors are grateful for the assistance of Dr A. Ansari, Head of Medical Illustration, University Teaching Hospital, Zambia in the preparation of Figs 1–3, and for permission from Penlon UK Ltd. to use Fig. 1.

References

1. Penlon Ltd UK. *User's Instruction Manual for Triservice.* 6545-99-211-5776. Abingdon.
2. Houghton IT. The Triservice anaesthetic apparatus. *Anaesthesia* 1981; **36:** 1094–108.
3. Schaefer H–G, Farman JV. Anaesthetic vapour concentrations in the EMO system. *Anaesthesia* 1984; **39:** 171–80.
4. Kamm G. Paediatric anaesthesia with the Ambu Paedi-Valve and bag. *Tropical Doctor* 1980; April: 66–71.
5. King M. ed. *Primary anaesthesia.* Oxford: Oxford University Press, 1986: 136–40.
6. Penlon Ltd UK. *Service manual for Triservice OMV.* 6515-99-211-5595. Abingdon.
7. Farman JV. The use of an air-entrainment device in conjunction with a draw-over vaporizer. A method for small children. *Acta Anaesthesiologica Scandinavica* 1966; **23** (Suppl.): 485 passim.

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The ethics of difficult tracheal intubation

We have recently faced an unusual dilemma of ethics related to anaesthetic practice.

A thirty-year-old female patient who suffered from subfertility presented for tubal surgery. She had extremely protruberant upper incisors and a receding mandible and because of this, two previous surgical procedures had been abandoned, after failure to pass a tracheal tube. The dilemma that faced the anaesthetic staff was outlined clearly to her. If tracheal intubation were achieved successfully for this elective procedure, any pregnancy which resulted from successful surgery would put her at risk of morbidity or even mortality should emergency anaesthesia be necessary, such as for an ectopic pregnancy, antepartum haemmorrhage of Caesarean section. The patient wished to proceed despite being fully informed of possible future anaesthetic risks. Consequently, an awake tracheal intubation was carried out under local anaesthesia. This proved extremely difficult and took an hour and fifty minutes to accomplish.

A technique that entails almost 2 hours in the anaesthetic room is obviously unacceptable for an emergency situation, therefore various options have been considered for the patient's future management. Spinal anaesthesia might be indicated for Caesarean section but we consider that a tracheostomy under local anaesthesia would be the best approach and indeed, we propose to perform an elective tracheostomy at 34 weeks of any pregnancy and to keep this patent until after delivery. The patient is agreeable to this.

Certain of our colleagues considered the best course would have been to decline to anaesthetise the patient rather than proceed and possibly put her at risk in the future. It was accepted that one might be called upon to administer general anaesthesia for many reasons other than pregnancy. However, electively to make strenuous efforts to anaesthetise her for a procedure that would greatly increase the chances of emergency anaesthesia being necessary in the future, was felt to be unacceptable. In our

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opinion it is quite reasonable to proceed with such cases, provided that the patients are kept fully informed of all risks and are still willing to carry on. It is also incumbent on the anaesthetist to plan ahead and to take such steps as are necessary to minimise the risks.

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Central and peripheral veins for drug administration

We read with interest the case report on cardiac arrest in near term pregnancy by Lindsay and Hanson (*Anaesthesia* 1987; **42:** 1074–7) in which Kuhn and co-workers[1] were quoted as finding that 'dye injected into a peripheral vein during cardiopulmonary resuscitation takes over 300 seconds to reach a central artery' and therefore recommended that 'drugs should be given via a central vein.'

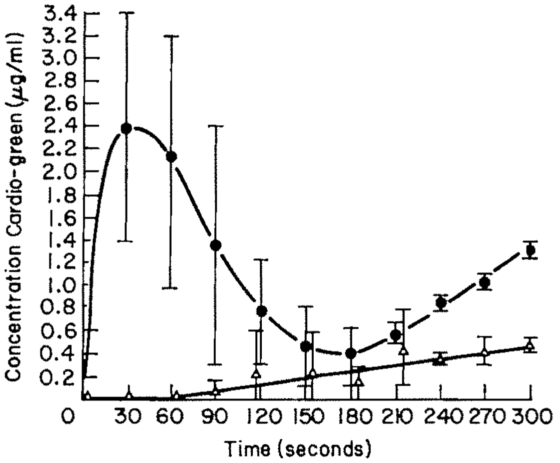

Fig. 1. Cardio-green concentration at femoral artery after injection by way of the right subclavian vein as opposed to injection via right basilic vein. ($p = 0.02$ at 30 seconds; $p < 0.005$ at 300 seconds. Data projected as means and one SDU). ●——●, central line dye injection; △——△, peripheral line dye injection.
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The advisability of using a central route for administration is not disputed. However, what Kuhn actually showed in her study was that after 300 seconds, no peak concentration of the dye was achieved from the use of antecubital veins, whereas a peak was achieved at 30 seconds when a central vein was used. The figure below shows that dye was present in the femoral artery 60–90 seconds after injection into a peripheral vein. This may not represent the situation when an infusion is used to flush the drug in at the peripheral vein. Perhaps this may warrant further studies.

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References

1. Kuhn GJ, White BC, Swetnam RE, Mumey JF, Rydesky MF, Tintinalli JE, Krome RL, Hoehner PJ. Peripheral vs central circulation times during CPR: a pilot study. *Annals of Emergency Medicine* 1981; **10:** 417–9.

Spinal anaesthesia for Caesarean section

Spinal anaesthesia for elective Caesarean section is still regarded as controversial despite the fact that a considerable proportion of obstetric anaesthetists use the technique regularly.

The paper by Michie, Freeman, Dutton and Howie (*Anaesthesia* 1988; **43:** 96–9) is therefore a welcome addition to the limited data available in British journals on the UK experience of this technique. Their article is also important in view of the withdrawal of heavy cinchocaine, an event which has caused some anxiety to many practitioners.

This is a summary of another, recently completed, double-blind trial (40 patients) who received between 0.5% bupivacaine in 8% dextrose and 0.5% cinchocaine in 6% dextrose (2.0 ml of each). The results confirm the observations of Michie *et al.* and may reassure anaesthetists that an appropriate alternative does exist. Bupivacaine had a significantly faster time of onset to T_4 (7.1 minutes – 10.2 minutes $p < 0.04$). Clinically this was very obvious at the 5-minute assessment when only one patient in the bupivacaine group had analgesic levels below T_8 compared to nine in the cinchocaine group. Table 1 shows the efficacy of analgesia tabulated for direct comparison with Michie *et al.* The results are comparable, though my unpublished experience with heavy bupivacaine suggests that 2.0 ml is less effective than 2.5 ml in terms of the number of patients who require analgesic supplements intra-operatively. This is also suggested by a comparison of the number of totally pain free patients (bupivacaine) in the study by Michie *et al.* with my results (Chi-squared test, $p < 0.04$).

Table 1. Efficacy of sensory block.

	Cinchocaine $n = 20$	Bupivacaine $n = 20$
A, painless	15	16
B, discomfort (no analgesia)	1	2
C, discomfort/pain (analgesia required)	4	1
D, general anaesthesia (after start of surgery)	0	1

Many patients in my cinchocaine group disliked the prolonged sensory block, but especially they complained of the prolonged complete motor block of their legs which lasted more then 3 hours. Scarcely any motor block remained in the bupivacaine group after 2 hours. Hypotension was similar in both groups (25%). This was because of the earlier (prophylactic) use of ephedrine, but there is still room for improvement to match the zero incidence obtained by Kang *et al.*[1] Two headaches occurred early and both patients had the 25-G needle inserted with the bevel perpendicular to the longitudinal fibres of the dura. This difference between the effects of parallel and perpendicular needle insertion was significant ($p < 0.01$).

The conclusions by Michie *et al.* are supported by my results and include the *caveat* on the limited duration of bupivacaine. This is usually only a problem if surgical complications slow down surgery or relatively inexperienced surgeons are working unsupervised. However, bearing in mind the fact that cinchocaine is no longer available I suggest that bupivacaine 0.5% in 6% dextrose should be regarded as the drug of choice for spinal anaesthesia in obstetrics.

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Reference

1. Kang YG, Abouleish E, Caritis S. Prophylactic intravenous ephedrine infusion during spinal anesthesia for cesarean section. *Anesthesia and Analgesia* 1982; **61:** 839–43.

Emergency spinal trays

General anaesthesia is often employed in urgent obstetric emergencies which require delivery by Caesarean section (for example, severe, persistent fetal bradycardia or umbilical cord prolapse) in an effort to minimise any delay in the start of surgery (or decrease the 'decision-to-incision' time).

The resident anaesthetist in many obstetric units prepares the necessary drugs and equipment for the rapid induction of general anaesthesia at the start of each working day. This is carried out in an attempt to minimise further the 'decision-to-incision' time. However, it is unusual to see similar advanced preparation for subarachnoid anaesthesia. A significant proportion of the time needed to establish subarachnoid anaesthesia may be taken up by preparation of the equipment preferred by the anaesthetist; this is more likely to be the case if the anaesthetic assistant is unfamiliar with both the technique and the location of the implements needed to perform it. It follows that, without such advanced preparation, there will be a bias towards the use of general anaesthesia in these urgent cases.

My practice is now to prepare, in advance, a box with the drugs, needles, syringes, introducers and gloves which I prefer for subarachnoid anaesthesia; this saves valuable time in an emergency situation. It seems reasonable to suggest that such advanced preparation for subarachnoid anaesthesia be undertaken by the resident anaesthetist in the obstetric unit, as part of his or her daily routine, if only to remove this unnecessary bias towards general anaesthesia for urgent Caesarian section.

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Unintentional dural puncture

We wish to comment on the paper 'Unintentional dural puncture: a survey of recognition and management' (R.W. Okell and J.S. Sprigge. *Anesthesia* **42:** 1110–2).

The authors appear to favour a loss of resistance to air technique to identify the epidural space. They also consider that this technique aids recognition of inadvertent dural puncture and quote from Dr. Crawford's book which states that the incidence of unintentional dural puncture is unlikely to be less than 1% in units in which anaesthetists in training perform epidurals.[1] We wish to take issue with both points.

We have performed 13 500 epidurals over 19 years and trained 54 anaesthetists *de novo*. There have been 35 inadvertent dural punctures; an incidence of 0.26%. Eight patients have suffered severe headaches and six received epidural blood patches. Six of the 35 dural punctures were caused by consultants, six by senior registrars and 23 by SHOs or registrars. Fifteen of the 54 junior anaesthetists trained have had one dural puncture and four have had two. Only 10 juniors have had inadvertent dural taps during their first 25 epidurals in the learning period.

All but 250 epidurals have been sited using loss of resistance to saline, based on the technique described by Doughty.[2] Our results confirm our impression that this is a technique that is both easily taught and readily learnt. Registrars and senior registrars trained elsewhere have been persuaded to conform since 1977. We venture to suggest that it is not just the technique but intense Consultant supervision and didactic teaching of juniors during the initial training period which has kept our dural tap rate so low.

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References

1. Crawford JS. *Principles and practice of obstetric anaesthesia*, 5th edn. Oxford: Blackwell Scientific Publications 1984: 214–20.
2. Doughty A. Dural puncture. Correspondence. *Anaesthesia* 1982; **37:** 469–70.

Identification of the caudal epidural space

One of the reasons for failure of caudal blocks in adults is difficulty in identification of the caudal epidural space, as a result of anatomical abnormalities and variations in thickness of the fat pad over the hiatus. We use a simple test to identify correct placement of a needle in the caudal epidural space, which is a modification of Moore's 'air test'.[1] When the needle is in the caudal canal, an assistant places a stethoscope in the operator's ears and holds the diaphragm firmly over the upper lumbar region, close to the midline. Two to five millilitres of air are rapidly injected after negative aspiration for blood and cerebrospinal fluid. Correct placement of the needle is confirmed by hearing a loud crunching sound which is transmitted from the caudal area. Should the needle lie outside the epidural space no sound is heard.

We have found this test very useful in the confirmation of correct placement of a needle in the caudal epidural space, and in particular it provides encouragement for beginners who are learning.

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Reference

1. Moore DC. Regional Block, 4th edn. Chicago, Illinois: Thomas, 1981: 447.

A complication of ilio-inguinal block for inguinal hernia repair

The letter by Lewis and Fell (*Anaesthesia* 1988; **43:** 249) was interesting. The complication described by them has indeed never been reported in adults after what is a commonly performed block.

Ilio-inguinal nerve block does not itself relieve pain after inguinal herniorrhaphy. This nerve, which originates from the L_1 root, supplies only the inguinal canal, the anterior superior portion of the scrotum and a small area on the inside of the thigh. The area involved in the wound of such an operation is innervated by the iliohypogastric nerve, thus *both* these nerves must be blocked to provide postoperative analgesia.

The authors' technique of blocking the ilio-inguinal nerve deserves special comment. They refer to the description of this block in a standard anaesthetic textbook,[1] but they in fact did not use this technique. V.v. Bahr in 'Eriksson' states that the needle should be inserted 2 cm *medial* to the anterior superior iliac spine, *not* 2 cm medial and *inferior* to this bony landmark; this inadvertent misplacement of local analgesia doubtless accounts alone for the complications that occurred in the two patients. Indeed, in a small patient (large child or small adult), this could place the needle on, or inferior to, the inguinal ligament and a block of the lateral cutaneous nerve of the thigh ($L_{2,3}$) and/or the femoral nerve (L_{2-4}) could result.

Drs Lewis and Fell comment correctly that this complication has been described in children,[2] however these cases and their own cannot be compared, since the blocks described by Shandling and Steward were carried out intraoperatively by the surgeon when normal anatomical planes had been disrupted and injections of local analgesia were possibly not localised around the iliohypogastric and ilioinguinal nerves. Finally their conclusion, that patients should be warned about this complication before operation, is invalid since the chances of femoral nerve palsy after ilioinguinal nerve block carried out properly, are so negligible that it may cause the patients undue anxiety.

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References

1. Bahr Vv. In: Eriksson E, ed. *Illustrated handbook of anaesthesia.* London: Lloyd Luke, 1979.
2. Shandling B, Steward DJ. Regional analgesia for postoperative pain in pediatric outpatient surgery. *Journal of Pediatric Surgery* 1980; **15:** 477–80.

Anaphylactoid reactions to prilocaine

One is less than reassured by the response (*Anaesthesia* 1988; **43:** 252) of Drs Watkins and Ruiz to my criticism of their paper on localised reactions to prilocaine administered for Bier's block. I am far from convinced that the reactions described were mediated immunologically, or that it was the local anaesthetic component of the solution that caused them and would still like an answer to the two specific questions.

Have the patients been told specifically that they are 'allergic' to local anaesthetic drugs? If they have, I believe that it was totally inappropriate to do so, on the evidence presented to date. Why was there no systemic reaction if the reactions were immunologically mediated? The authors claim that none occurred (to either prilocaine or the preservative in the solution used) because of 'whole-body dilution', but surely Type B drug reactions are, by definition, not dose-related.

There are two reasons why these points are important. The authors claim for themselves in their reply the authority of the National Adverse Anaesthetic Reactions Advisory Service. If this Service is to continue to have the support of the specialty, it must take a much wider view of the possible causes of drug reactions than has been demonstrated on this occasion. My second reason is their rather cryptic reference to 'seven delayed systemic reactions to epidurals'. The implication is that they have information on immunologically-based reactions that occurred some time after drug administration. These cases should be published because delayed immunological reactions to local anaesthetics have not, to my knowledge, been described.

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A visit before operation

In her letter stressing the importance of the pre-operative visit (*Anaesthesia* 1988; **43:** 51–2) Dr Dobson referred extensively to an article of which we are the surviving authors.[1] She states that we seem to suggest that a personal visit before operation by an anaesthetist is time-consuming and inefficient, and that an equally good method (presumably of pre-operative assessment) is a telephone call from house surgeon to anaesthetist.

Our findings were published two and a half years ago and because memories fade, we quote the relevant section of our article. 'This study confirms the conclusion of Lunn and Mushin[2] of "inadequate consultation between surgeon and anaesthetist". The unaided perusal of notes or examination of patients on the ward or in the theatre must be a time-consuming and inefficient method of gaining knowledge much of which is already known to the surgical team.

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at the Association of Anaesthetists Meeting
in Southampton 14-16 September

Because discussion with senior surgeons is exceptional the practice of the house surgeon telephoning the anaesthetist should perhaps remain as part of an integrated approach for assessment.'

Throughout our article, which was a survey not of our practice but of that of 415 anaesthetists in the British Isles, we bemoaned lack of consultation between surgeon and anaesthetist and expressed surprise that only 48% of anaesthetists regarded formal pre-operative assessment as a contractual obligation. The use of the word 'unaided' was carefully chosen. It was intended to convey not our approval of failure to visit patients before surgery but our disapproval of failure of consultation between anaesthetist and surgeon. Our later remarks in the article did suggest that anaesthetists had judged well in being unoptimistic about the possibility of allocating more resources to achieve the required changes but this must not be interpreted as endorsing failure to visit pre-operatively wherever possible.

Nowhere in our article did we suggest that an equally good method of pre-operative assessment was a telephone call from house surgeon to anaesthetist. We stated most specifically that it was merely part of an integrated approach to pre-operative assessment. Dr Dobson continued by asking if we really consider that the training and experience of an anaesthetist were equivalent to those of a house surgeon and whether or not personal contact between patient and anaesthetist contribute nothing to the care of the patient. Of course they are not and nothing we wrote could be construed to suggest they are. The suggestion that personal contact contributes nothing could only stand if we were guilty of any of the other charges.

We agree with much of the rest of her letter but we do feel like the newscaster who is actually blamed for the bad news he has to read. We believe our late colleague Alan Jennings (of happy memory) would have agreed with what we have said but he might have put it more robustly.

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References

1. CURRAN J, CHMIELEWSKI AT, WHITE JB, JENNINGS AMC. Practice of pre-operative assessment by anaesthetists. *British Medical Journal* 1985; **2:** 391–3.
2. LUNN JN, MUSHIN WW. *Mortality associated with anaesthesia.* London: Nuffield Provincial Hospitals' Trust.

Anaphylactoid reaction to vecuronium

In reply to the questions posed at the end of the case report by Farrell *et al.* (*Anaesthesia* 1988; **43:** 207–9) I would like to draw attention to the use of an *in vitro* test which would enable the authors to tell their patient which neuromuscular blocking agents she can be given safely in the future.

The leucocyte histamine release test as described by Assem *et al.*[1] measures the release of histamine from the patient's leucocytes when incubated with various anaesthetic agents. It is a test free from hazard to the patient, and should abnormal histamine release be shown in response to vecuronium, (and perhaps tubocurarine), would support substantially the diagnosis of an anaphylactoid reaction and specifically indicate the causative agent.

These tests are expensive;[2] however, this expense could be justified when compared with the cost of medicolegal action which may ensue if the causative agents of these anaphylactoid reactions are not identified, and the patient informed of them.

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S.M. CHARLTON

References

1. ASSEM ESK, FROST PG, LEVIS RD. Anaphylactic like reaction to suxamethonium. *Anaesthesia* 1981; **36:** 405–10.
2. PUSEY JM, CHARLTON SM, SKINNER JB, ASSEM ESK. Anaphylactoid reaction to alcuronium. *Anaesthesia* 1987; **42:** 164–7.

A reply

We thank Dr Charlton for comments on our case report.

Dr Assem's leucocyte histamine release test deserves wider publicity than it enjoys at the moment. The use of this procedure or perhaps the technically simpler Benveniste basophil degranulation test might well be considered in our follow up of this patient. However, no matter how valid these procedures are for investigating reactions retrospectively, their use as *prognostic* indicators about the patient's sensitivity to other agents for use in the future may provide false security. A minority of reactions (perhaps 20%) are, in my opinion, genuinely drug specific and the majority implicate nonspecific situations such as drug interactions, direct mediator (e.g. histamine) release often additive or synergistic to several drugs, and idiosyncrasy. The latter mechanisms are no less hazardous to life than the immune reactions and are manifest in similar *anaphylactoid* characteristics, cutaneous, pulmonary and cardiovascular. Nevertheless, the comments in the last paragraph of Dr Charlton's letter are certainly valid within the present medicolegal climate.

Overall, the investigation of anaphylactoid reactions remains a complex business with no single test or single discipline providing all the answers. Various European laboratories now have working protocols, including our own[1] and readers may be interested to peruse these.

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Reference

1. WATKINS J. Investigation of allergic and hypersensitivity reactions to anaesthetic agents. *British Journal of Anaesthesia.* 1987; **59:** 104–11.

Hazard of continuous epidural infusion of local anaesthetic

An unusual and potentially dangerous hazard of continuous epidural infusion of local anaesthetic in obstetrics is reported. The patient was a primagravid 31-year-old who requested an epidural. After easy insertion of an epidural catheter at L_{1-2} a test dose and initial dose which totalled 10 ml of bupivacaine 0.375% was given. Blood pressure remained constant. The catheter was connected according to our usual hospital practice to a 60-ml syringe (Sabre Gillette which contained 55 ml of 0.25% bupivacaine) in a Vickers syringe pump. This solution was infused at 8 ml/hour. (Each labour room bed has a syringe pump mounted permanently on a bar bolted to the wall above the patient's head). This technique has been used in this hospital for 2 years without any problems in approximately 1000 patients.

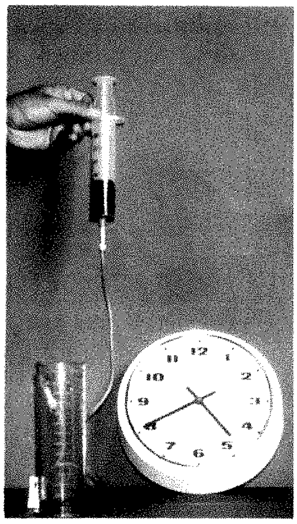

Fig. 1.

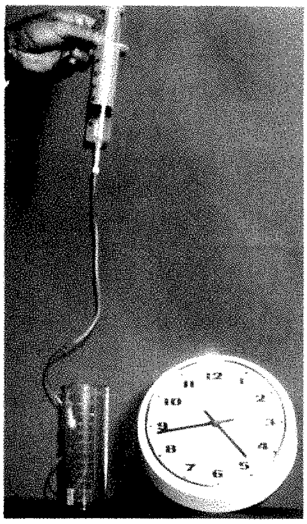

Fig. 2.

When the epidural block was working well about 30 minutes later the anaesthetist left. The blood pressure decreased to 70/40 mmHg about one and a half hours later (without any signs of fetal distress). Crystalloid was infused rapidly and the syringe pump switched off. The 60-ml syringe was then discovered to contain 7 ml of bupivacaine and 32 ml of air; the plunger had moved the expected distance during the 2 hours of infusion. Analgesia reached to T_4, and she was unable to move her legs, (she was not distressed because she had been warned that her legs might become weak). The missing 32 ml of bupivacaine could not be found, so it was concluded that it had inadvertently leaked into the patient's epidural space. No further local anaesthetic was given and 4 hours later the patient, with satisfactory analgesia delivered a healthy baby. She did not have a post-delivery headache and she expressed satisfaction with the epidural, (despite knowledge of the problem which had occurred.)

The syringe was examined for faults. Compression of 30 ml of air or liquid in the syringe did not produce a leak past the plunger, neither did withdrawal of the plunger of the empty syringe (with the nozzle occluded). However, with the syringe loaded and held vertically (nozzle down) liquid readily ran out of the syringe (after an initial delay) while air leaked into the syringe past the plunger. This situation is illustrated by Figs 1 and 2.

It appears that because of a faulty seal between syringe plunger and barrel, our patient accidentally received 80 mg of bupivacaine in addition to the 77.5 mg which was intended over a 2-hour period. It is noteworthy that simple examination and testing of the syringe could not detect this fault and switching off the syringe pump did not stop the leak of bupivacaine. We have attempted to avoid further similar incidents by lowering the syringe pump mounting rail below the level of the patient, and instructing our midwives to report the presence of air inside the syringe.

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D.A. ORR
I.M. BALI

Syringe drivers

Syringe drivers are used frequently to administer continuous infusions of opioid analgesics. We wish to draw attention to a potential hazard with these devices, which may deliver much greater dosages of drugs than intended in certain circumstances. There have been several recent incidents in this hospital all of which involved the use of continuous infusions of diamorphine through central venous lines, in which an inappropriately rapid rate of drug delivery occurred despite normal function of the syringe driver. The basis of this problem is that the syringe driver is a mechanical device which advances the plunger of a syringe at a fixed rate but with no restriction on forward movement of the plunger ahead of the driver.

We have observed an increased flow rate as a result of elevation of the syringe driver above the site of infusion, as for example when placed upon a bedside locker with the patient supine in bed. This prompted the following experiment. A standard 10-ml (B-D) syringe that contained 10 ml water was suspended at various heights above the end of a selection of extension tubings connected to the syringe. The volume of water collected from the end of the extension tubing over a 5-minute period was measured and the calculated flow rates in ml/hour are shown in the table. It can be seen that significant volumes may be delivered when the syringe is connected by a standard extension set without any pressure on the syringe plunger. However, this may result in the inadvertent delivery of a significant dose of drug when connected to a central venous line. A simple device is now available from the manufacturers of the widely-used Graseby syringe driver which clamps the syringe plunger onto the actuator assembly of the driver, and thereby prevents unrestricted forward movement. This is particularly recommended where infusion through a wide bore central venous catheter is to be used and has now become an integral part of the design of other makes of syringe driver.

Table 1. Flow rate (ml/hour).

	Height above end of extension tube (cm)			
Infusion set	15	20	25	30
Butterfly extension set 0.5 mm internal diameter	–	–	–	1.2
100 cm extension tube 1.0 mm internal diameter	–	< 1.2	2.4	7.2
150 cm extension tube 1.5 mm internal diameter	1.2	1.8	3.6	7.2

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A simple CPAP system during one-lung anaesthesia

Continuous Positive Airway Pressure (CPAP) to the nonventilated, nondependent lung improves oxygenation during one lung anaesthesia.[1,2] Previously described systems may be complex, or cumbersome to use.[3–5]

A system can be constructed from 15 mm paediatric components: two Y-shaped T-pieces (Portex 100/276/000)

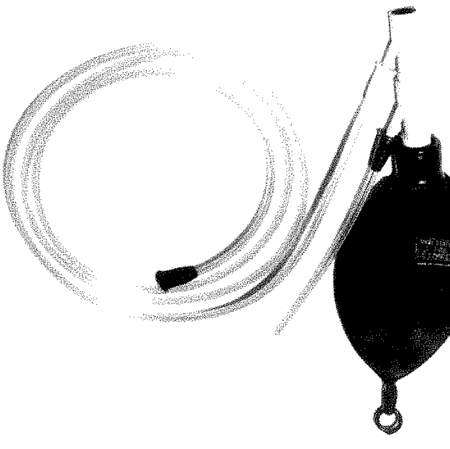

Fig. 1.

Table 1. Fixed oxygen flow, 5 litres/minute.

Length of exhaust tubing* (mm)	Airway pressure (kPa)
700	1.5
400	1
180	0.5

* Measurements made with Life Care oxygen tubing.

Table 2. Fixed, 180 mm length of exhaust tubing (Life Care).

Oxygen flow (litres/minute)	Airway pressure (kPa)
10	1.6
8	1.0
5	0.5

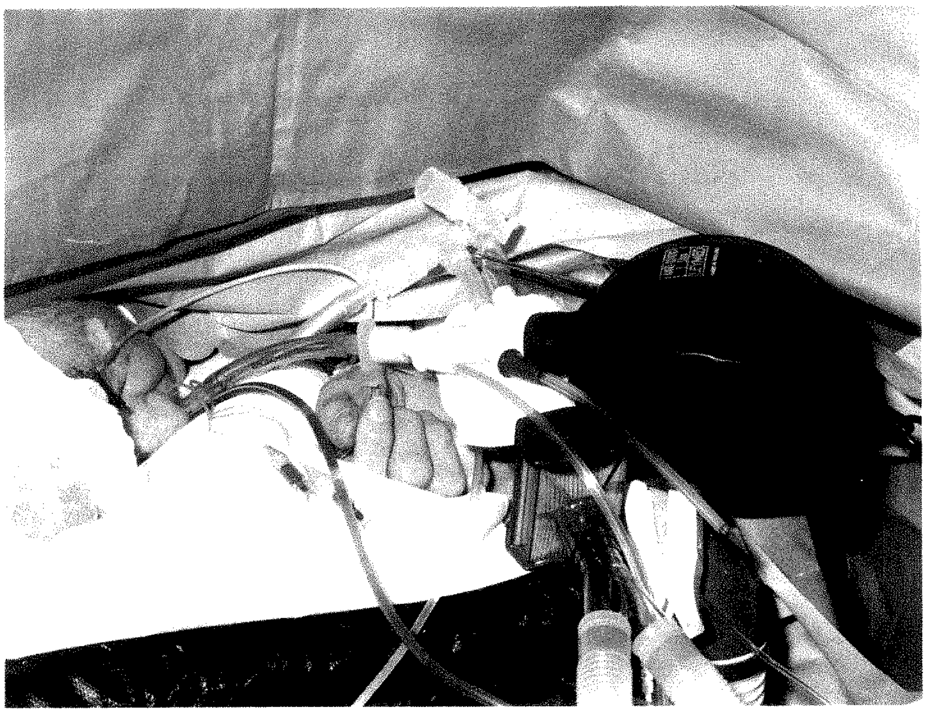

Fig. 2.

and a one-litre reservoir bag on a bag mount (Portex 100/277/000) are connected in series (Fig.1). Fresh gas (oxygen) flows into one T-piece and exhausts through open-ended plastic tubing attached to the other T-piece. Airway pressure depends on the oxygen flow rate, and the length/resistance of the exhaust tubing. A water manometer and a tracheal tube in a syringe barrel were used during construction to calibrate and select appropriate lengths of locally available tubing for desired levels of CPAP.

In use, it is easy to position the device on the pillow close to the patient as it is compact and light in weight (Fig. 2). It provides CPAP and allows manual inflation of the lung at the surgeon's request when connected to the bronchial tube. We use the device in this simple form; others may wish to incorporate an anaeroid manometer on a third T-piece, or modify the design in other ways.

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References

1. CAPAN LM, TURNDORF H, PATEL C, RAMANATHAN S, ACINAPURA A, CHALON J. Optimization of arterial oxygenation during one-lung anesthesia. *Anesthesia and Analgesia* 1980; **59:** 847–51.
2. OBARA H, TANAKA O, HOSHINO H, KAETSU H, MAECKAWA N, IWAI S. One-lung ventilation. The effect of positive end expiratory pressure to the nondependent and dependent lung. *Anaesthesia* 1986; **41:** 1007–10.
3. THIAGARAJAH S, JOB C, RAO A. A device for applying CPAP to the nonventilated upper lung during one-lung ventilation, I. *Anesthesiology* 1984; **60:** 253–4.
4. HANNENBERG AA, SATWICZ PR, DIENES RS, O'BRIEN JC. A device for applying CPAP to the nonventilated upper lung during one-lung ventilation, II. *Anesthesiology* 1984; **60:** 254–5.
5. BARAKA A, SIBAI AN, MUALLEM M, BAROODY M, HAROUN S, MEKKAOUI I.T. CPAP oxygenation during one-lung ventilation using an underwater seal assembly. *Anesthesiology* 1986; **65:** 102–3.

Anaemia and Jehovah's Witness

We are concerned by a statement which related to colloid oncotic pressure made by Hasibeder and colleagues (*Anaesthesia* 1988; **43:** 255) in response to the case report by Howell and Bamber (*Anaesthesia* 1987; **42:** 44–8). Hasibeder *et al.* quote a colloid oncotic pressure of 10.13 kPa (76 mmHg) for 'Haemaccel' solution, when measured with a Knauer-Oncometer, using a membrane which rejects particles in excess of 10 000 daltons (that is, the figure derived relates to the oncotic activity of all particles whose molecular weight exceeds 10 000 daltons.) Particles of this size are known to cross physiological membranes for example, in the glomerulus, although size, shape and charge are also important. The mean molecular weight of albumin, said to be the major oncotically active particle in plasma, is 67 000 daltons. The choice of membrane pore 'size' (and its 'rejection' characteristics) would appear to be crucial both in measurement, and, more importantly, in the interpretation of the physiological significance of the figure quoted for colloid oncotic pressure.

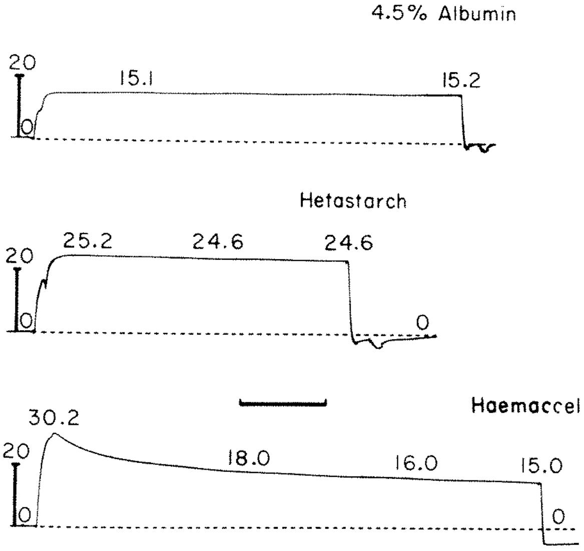

Fig. 1. Displayed oncotic pressure: time plot for 4.5% albumin, hetastarch and Haemaccel. A one-minute time bar is shown. The left hand bars represent 0 (atmospheric pressure) to 20 mmHg pressure gradients. Figures above the pressure trace are the actual oncotic pressure (mmHg). The steps in the initial upward deflections are artefacts as a result of injection of the solutions into the measuring chamber. Steps after flushing, with rapid return to baseline, are seen with albumin and hetastarch. The post measurement 'negative' pressure after flushing of 'Haemaccel' is seen easily, and is off scale (− 10 mmHg).

We measure routinely oncotic pressure in all patients in the Intensive Therapy Unit (ITU) on admission, and thereafter, at least daily. We use an Instrumentation Laboratory Weil Oncometer. The membrane pore size is quoted as rejecting particles whose molecular weight exceeds 30 000 daltons. Oncotic pressure in normal adults measured with this system is quoted as 21–26 mmHg (2.79–3.47 kPa). This is confirmed by our own observations. Albumin solution (4.5%), provided by the National Blood Transfusion Service, has an oncotic pressure of 14.5–15.5 mmHg (1.93–2.06 kPa) (batch dependent, personal observations). A solution of 4.5% albumin solution introduced into the Weil oncometer develops a stable oncotic profile (Fig. 1, oncotic pressure: time plot). Hetastarch (Hespan) has a similar oncotic profile, with a stable oncotic pressure of approximately 26 mmHg (3.47 kPa). The introduction of polygeline (Haemaccel) into the measurement chamber yields an initial oncotic pressure of approximately 30 mmHg (4 kPa) which decreases progressively to less than 15 mmHg (2 kPa) at 6 minutes. The decline continues, but is not illustrated.

These observations are reproducible and suggest that oncotically active polygeline particles cross this 30 000 dalton rejection membrane, unlike those active particles in either 4.5% albumin solution or hetastarch. The thesis is confirmed by the 'negative' pressure displayed on the instrument after the flushing of polygeline from the system: particles are trapped on the measurement side of the membrane and act oncotically for some time before diffusing back to the measuring chamber. This 'negative' phase is transient for either albumin or hetastarch and is at least partly because of simple mechanically applied pressure necessary to flush the measuring chamber. The clinically observed diuresis after infusion of polygeline suggests that many small particles traverse the glomerular membrane (the counterpart to our measuring membrane) and are excreted, presumably acting additionally as an osmotic diuretic.

It appears from these observations, that polygeline might be an inappropriate solution for the maintenance of oncotic pressure in the circumstances described by Howell and Bamber. It is oncotically active, but small molecules may cross membranes relatively easily and could contribute to the formation of alveolar and peripheral oedema, the latter a feature observed by Howell and Bamber. Howell and Bamber's worries about the development of pulmonary oedema and the oncotic properties of Haemaccel, appear justified in the light of their inability to measure oncotic pressure.

This debate will continue until oncotic pressures are measured and quoted against membrane pore size. We do not yet know whether the choice of a '30 000' pore-size membrane in the Instrumentation Laboratory Weil Oncometer, or the '10 000' pore-size in the Knauer Oncometer is the most appropriate 'physiological' size. However, it would appear that the choice of a '30 000' membrane, yields a figure which relates closely to the pulmonary artery occlusion pressure PAOP) and the presence of pulmonary oedema, in patients who suffer from 'cardiogenic' (non-leaky) oedema. We aim in this ITU, to ensure that oncotic pressure exceeds PAOP and we treat patients to ensure that this is achieved, either by the use of vasodilators or the infusion of oncotically active (and stable) particles (albumin or hetastarch). In these circumstances, we do not use Haemaccel.

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H. Panchal

Inadvertent common carotid artery cannulation?

A 76-year-old man was admitted to the casualty unit unconscious, pale, centrally cyanosed and hypotensive. Abdominal examination revealed the presence of a large pulsating mass, probably an aneurysm of the abdominal aorta. The patient's trachea was intubated and his lungs ventilated with 100% oxygen but he developed an asystolic cardiac arrest which responded to external cardiac massage, atropine, and adrenaline. He was given 2000 ml gelofusine

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Monitoring and Patient Safety

A special issue of "Anaesthesia and Intensive Care",
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through two large peripheral venous lines and transferred to theatre for a laparotomy.

The patient was prepared for central venous cannulation but again became centrally cyanosed, developed a bradycardia of 20 beats/minute and a blood pressure of 45/20 mmHg. The administration of further fluid and atropine 1.2 mg improved the patient's cardiovascular status. Central venous cannulation of the right internal jugular vein was attempted using a low approach with a 14-G Ledercath, but carotid cannulation was suspected when deoxygenated blood pulsed upward towards the giving set. The cannula was removed and pressure applied to the entry site.

The laparotomy was started and a further attempt made at cannulation of the right internal jugular vein but again blood pulsed from the cannula towards the giving set. Connexion to a pressure transducer produced a trace consistent with arterial cannulation (pressure 72/34 mmHg). However, a venous trace became apparent (pressure 6/0 mmHg) when the aortic cross clamp was applied. Further exploration by the surgeon revealed the presence of an aortocaval fistula. The fistula was ligated and a dacron trouser graft sewn into position. The patient made an uncomplicated recovery and was discharged from hospital three weeks later.

This case is reported in order to emphasise that although common carotid artery cannulation is sometimes difficult to recognise when the patient is hypotensive and centrally cyanosed, it is particularly difficult to differentiate between venous and arterial cannulation if an aortocaval fistula coexists.

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Pain during injection of vecuronium

Dr Kent and colleagues in their letter (*Anaesthesia* 1988; **43:** 337) describe the pain during injection of vecuronium and mention that they were not aware of other reports of this side effects. This was first reported in a study of 100 patients in whom the incidence of pain was high with 4 mg/ml[1] from the original ampoule of vecuronium; pretreatment with alfentanil and fentanyl did not make any difference. Dilution of vecuronium to 2 mg/ml reduced significantly the incidence and severity of pain. The change in dilution of vecuronium from 4 mg/ml to 2 mg/ml was suggested. Vecuronium is now marketed with 5 ml diluent, which after reconstitution is 2 mg/ml. The cause of pain is not known but Cozanitis[2] suggests it is because of low pH (3.8) of vecuronium. Dr Kent and colleagues report the pH of vecuronium is 4.5 (approximately). Perhaps a slight change in the acidity of vecuronium after new formulation has changed the incidence and severity of pain.

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References

1. KUMAR CM. A hazard with vecuronium. *Anaesthesia* 1985; **40:** 1018.
2. COZANITIS DA. Pain with vecuronium. *Anaesthesia* 1986; **41:** 434.

Damage to a laryngoscope

This is a report of an unusual complication of laryngoscopy. A loud 'cracking' sound was heard during a rapid-sequence intubation as the laryngoscope was passed down the right side of the tongue, together with some involuntary movement of the laryngoscope. An immediate inspection of the mouth revealed no obvious cause for this event and intubation was completed uneventfully.

The screw was found to be broken just above the thread when the laryngoscope was examined afterwards. The thread remained embedded in the handle. The laryngoscope in the open position was held together by the spring which is why it was possible to complete laryngoscopy in this case. Nevertheless this incident could lead to aspiration of part of the broken screw or to dental damage during the associated involuntary movement of the laryngoscope. Fortunately in this case no complications arose.

The screw was made of brass and the broken surface showed signs of metal fatigue. This would not be detected in the routine pre-operative check of equipment carried out by the anaesthetist unless the screw actually broke during the inspection itself. A screw made of stainless steel might be less liable to this complication.

There is no report of breakage of the screw which connects the handle to the laryngoscope blade, revealed by a computer search of the literature back to 1966.

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Total intravenous anaesthesia for military surgery

We were most interested in the findings and views presented by Dr Restall and his coworkers (*Anaesthesia* 1988; **43:** 46–9). We believe that anaesthetic history as well as recent experience proves the value of inhalational anaesthesia although we bow to the supreme expertise of British anaesthetists, who have taken active part in many wars (most recently, the Falklands conflict) whilst Sweden enjoyed 200 years of peace.

As early as during World War I Flagg observed:[1] 'A slow recovery requires the presence of a nurse or an attendant who might be useful elsewhere . . .'. Even in the hands of experienced nurse anaesthetists and anaesthetists, we find that the infusion rate of anaesthetic drugs often is kept a little above minimum to ensure undisturbed working conditions for the surgeon. We pay for this, however, a high price at the end of the operation, when we have to wait for the excess amount of drug to be metabolised.

It would be interesting if Dr Restall *et al.* would comment in detail about the cases who took more than 60 minutes to recover.

We aim, in the training, planning and selection of methods for war-time anaesthesia in Sweden,[2] to achieve what Jowitt and Knight[3] reported from Ajax Bay: an average interval between the end of inhalation anaesthesia to response to command of less than 5 minutes. We prefer to use inhalation anaesthesia (at present halothane) at the time of primary surgery, and to reserve intravenous techniques (neuroleptanalgesia) for second operations which take place under more stable circumstances.

The need for tracheal intubation was not great in Jowitt's series: 18% cases had to wait more than 15 hours for surgery.[4] The necessity for tracheal intubation was therefore much reduced. Secondly, we suggest that the muscle relaxant component that Dr Restall *et al.* used adds complexity but reduces the flexibility of the method. Few operations in the field will need continuous muscular relaxation, and in our opinion, a better way of administering a relaxant (vecuronium, atracurium or suxamethonium) would be in incremental doses as needed. Spontaneous ventilation might actually be preferable for a large number of cases, so that the hands of the unassisted anaesthetist (the number of ventilators for theatre use in wartime in Sweden is at present insufficient) would be freed.

Finally, we consider personally that the costs of first rate anaesthetics such as isoflurane are minute compared to the total expenditure of war, or the preparation for war, especially since the medical organisation is so essential (even to the extent of limiting the total war effort), and therefore must be justified.

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References

1. FLAGG PJ. Anaesthesia in Europe on the Western Battle Front. *International Clinics* 1918; **3:** 210–28.
2. DALENIUS E, ÅSÅKER B-M. Training for war-time anesthesia in Sweden. *American Assistant Nurse Anaesthetist's Journal* 1988 (in press).
3. JOWITT MD, KNIGHT RJ. Anaesthesia during the Falklands campaign. The land battles. *Anaesthesia* 1983; **38:** 776–83.
4. JOWITT MD. Anaesthesia for battle injuries (correspondence). *Anaesthesia* 1984; **39:** 943–4.

The article by Dr Restall and his colleagues (*Anaesthesia* 1988; **43:** 46–9) about total intravenous anaesthesia for military surgery was very interesting. My own experience in this field comes from administering anaesthetics in the besieged refugee camp of Chatila, West Beirut, in 1987. The technique described is undoubtedly an excellent one but I suggest that oxygen, vecuronium, midazolam and syringe pumps may be unobtainable luxuries in many of the world's current battle zones.

However, my own impressions support many of the observations made. Promethazine (for elective cases) and alcuronium instead of midazolam and vecuronium was a technique which proved simple and effective, with quick recovery; the patients were soon able to maintain their own airways. Similarly, there was a low incidence of postoperative vomiting and emergence phenomena. Notwithstanding this, emergence phenomena is relatively less important in a soldier injured in battle who undergoes a safe anaesthetic and successful operation, than in a patient for routine surgery on the NHS.

My own observations also support the view that analgesia after ketamine administration outlasts the period of anaesthesia and that the analgesic effect occurs at subanaesthetic doses. Ketamine can be used to provide useful analgesia in subanaesthetic doses when positioning patients with fractured necks of femur for their spinal anaesthetic.

Finally, did hypocapnia from controlled ventilation of patients' lungs at 120 ml/kg/minute contribute to the anaesthetic effect?

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A reply

Thank you for the opportunity to reply to these letters.

We also are students of military history and appreciate that inhalational anaesthesia has been the safest and most commonly used method of anaesthesia since the introduction of general anaesthesia to military practice in the Americo–Mexican war of 1847.[1]

Anaesthetists in both world wars attempted to use intravenous techniques but the ideal drugs and equipment were not yet available. Chemical warfare is no longer only just a threat and we must be prepared to work in an environment which is protected against such an attack. Clean air will be at a premium and pollution of the theatre atmosphere by exhaled anaesthetic agents would have a deleterious effect on the staff. The British Army is investigating this problem but the work is unpublished.

There is no question that quick recovery has been and must be a foremost aim of military anaesthetists. Our technique allows recovery which in speed and safety is comparable with any other general anaesthetic method. Spontaneous ventilation with inhalational agents does not provide more rapid recovery particularly if the patient has to be in the care of a nonanaesthetic specialist. The three cases which took 60 minutes or more to recover were surprising and disappointing. However, midazolam is extensively biotransformed by hepatic enzymes via oxidation to hydroxylated metabolites. It is likely that approximately 5% of the population are poor metabolisers of midazolam.[1] In future this problem can probably be overcome by the administration of Ro 15-1788 (anexate) to those patients in whom recovery is delayed. We do not shift from our opinion that all battle casualties must be intubated irrespective of the time interval since wounding. The acutely traumatised patient must always be assumed to have a full stomach. Gastric emptying ceases at the time of trauma. The mechanisms may be multiple and involve anxiety and fear, sympathetic stimulation, pain, shock and treatment with narcotic analgesics.[2]

We used vecuronium in our series of 100 cases in the infusion mixture. We have demonstrated that it is compatible with ketamine and midazolam, but that it is possible to use only an initial bolus dose or intermittent bolus doses. Surely it is preferable that the nonanaesthetist should not have to decide when further doses of relaxant are required if the care of the patient has to be left to him or her? We give vecuronium continuously through a second syringe pump in our normal peacetime practice.

Trichloroethylene production has been stopped by Imperial Chemical Industries. It may be that isoflurane will be the inhalational agent of the future for drawover anaesthesia. We are not convinced that blood pressure will be maintained in hypovolaemic patients who breathe spontaneously. The cost would be high and unfortunately the medical vote of the military is not always directly related to the ordnance vote.

We appreciate that oxygen, vecuronium, midazolam and syringe pumps are not readily available in all the world's current battle zones. The supply of oxygen worries us and therefore we are pleased to report that added oxygen is not essential for our technique. The $Sa\text{O}_2$ of these patients ventilated with air will be considerably better than those breathing spontaneously using inhalational agents and a drawover technique. We chose vecuronium because of its excellent and almost unique storage qualities. Midazolam, because it is water soluble, must be the benzodiazepine of choice for most purposes at the present time and costs little more than promethazine and diazepam. Syringe pumps can be sophisticated but the more robust and simple ones cost about the same as the simplest vaporizer. Ketamine should be available in battle for its anaesthetic and analgesic properties. It is a considerable bonus that the emergence phenomena can be prevented by the concurrent use of midazolam.

Total intravenous anaesthesia is now a possibility in battle and in the Third World. Safe and reliable drugs are obtainable at reasonable cost and the simple, quantitative means of delivery of these drugs is now available.

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References

1. Carlisle RJT, Dundee JE, Harper KE, Collier PS. Aberrant elimination half-life of midazolam. *British Journal of Anaesthesia* 1985; **57**: 834 P.
2. Giesecke AH, Egbert LD. Anesthesia for trauma surgery. In: Miller RD, ed. *Anesthesia*, 2nd edn. New York: Churchill Livingstone, 1986: 1824.

Pre-oxygenation attachment for the Triservice apparatus

Pre-oxygenation is well recognised as a safeguard before the induction of emergency anaesthesia. The Triservice apparatus allows oxygen supplementation, using a reservoir tube and T-piece. The oxygen cylinder valve provided with the apparatus will only deliver 4 litres/minute; similarly most oxygen concentrators available supply a maximum of 4 litres/minute of 95% oxygen. Anxious, unpremedicated patients are likely to have a high minute volume when asked to breathe deeply during pre-oxygenation. An oxygen supplement of 4 litres/minute during pre-oxygenation with a minute volume of 20 litres/minute will result in a $F\text{IO}_2$ of less than 0.4.

An extra oxygen reservoir can be provided temporarily at the open end of the reservoir tube. A plastic bag 100 × 50 cm is fitted around a piece of disposable plastic breathing system tubing, which has been fenestrated to ensure that the outlet does not become occluded. The attachment is fitted to the reservoir tubing with a standard male tubing connector. The bag holds about 40 litres of oxygen which is collected over 10 minutes in preparation for pre-oxygenation. The patient then breathes the contents of the bag through the drawover apparatus. Oxygen supplementation continues as usual after the airway is secured. The attachment is easy to use, inexpensive, portable and may be employed with either the Triservice or EMO drawover anaesthetic systems.

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Do we need blood warmers and what flow rates are relevant?

The statement of Walters *et al.* (Anaesthesia 1988, **43**: 30–32) about the efficiency of blood warmers is certainly correct at a flow rate of 9 litres/hour. We lack the opportunity to use such an amount of cold blood through a single intravenous catheter.

It is advisable to examine warming devices in the clinical circumstances that they will be used that is, in the operating room. Modern air-conditioning systems produce frequent air changes and low ambient temperatures so the patient is in constant danger of hypothermia. The warming of all infusions/transfusions is necessary to prevent this. It is in this type of environment that the warming device should be tested. Furthermore the most frequently used flow rates of infusions and transfusions should be employed. More than 90% of all transfusions administered during operations are given at less than 2.5 litres/hour. Additional vein access rather than faster flow speeds of individual infusions are used to achieve higher flow rates.[1]

The clinical approach differs from the experimental data of Walters *et al*: the IFT 200 proves superior in the relevant flow range up to 3 litres/hour.

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Reference

1. Nagler, J. Intraoperative Infusionstherapie. Auswertung der Zufuhrraten und Prüfung der Effektivität von Infusionswärmern. (Intraoperative infusion therapy. Evaluation of flow rates and examination of the effectiveness of infusion warmers.) *Infusionstherapie* 1986; **13**: 216–9.

Oesophageal detector device

Congratulations to Dr Wee on his article (*Anaesthesia* 1988; **43**: 27–9) which described an oesophageal detector device. Dr Wee thought this was a new idea, but as so often happens, this is not the case. Dr Junius and myself described the identical test in a poster, displayed at the VII World Congress of Anaesthesiology at Hamburg in 1980. Dr Wee would not have known that if he was not present at that Congress.

A most important clinical point arises from the experience of many anaesthetists with the method over many years. There will be a proportion of doubtful or misleading results with it if the instructions as set out in the article are followed literally. It is essential that, as a matter of routine, the cuff on the tracheal tube is deflated before the aspiration test, otherwise there will be some instances when the tube is really in the trachea but there will be sufficient resistance to aspiration to cause confusion in interpretation. This may lead to loss of valuable time in the detection of the true cause of advanced hypoxia, when a change of tube is wrongly thought to be necessary. On the other hand, when the test is applied with the cuff deflated, the difference in results between the two locations is dramatic and always easy to detect. Cricoid pressure may be used simultaneously while the cuff is momentarily deflated, if the test is applied in a patient who may have stomach contents.

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B. Pollard

A reply

Thank you for the opportunity to reply to Dr B. Pollard.

Firstly, I had no idea that Drs Junius and Pollard had described an identical test in a poster presentation at the VII World Congress of Anaesthesiology at Hamburg in 1980; I was a third year medical student at that time and was neither present at the Congress nor had I ever read a report of its proceedings! Drs Junius and Pollard did not mention their test in their article[1] in which they gave a comprehensive account of the methods used to distinguish oesophageal from tracheal intubation.

Secondly, I cannot comment on the importance of deflation of the cuff before the test other than to say that in the study I carried out, all the tracheal tubes had their cuffs inflated with 3–5 ml air to simulate normal procedure after intubation and to secure the airway; and out of 100 first time tests with the oesophageal detector device there was only one doubtful result which was because of the presence of thick secretions that blocked the tracheal tube. Further use of the device since the study did not raise any doubts with regard to cuff inflation, but I agree that an overinflated cuff could conceivably occlude the lumen of the tracheal tube and give a false result.

Finally, I thank Dr Pollard for restressing the importance of carrying out the test as described in my article to avoid the possibility of misleading results.

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Reference

1. Pollard BJ, Junius F. Accidental intubation of the oesophagus. *Anaesthesia and Intensive Care* 1980; **8:** 183–7.

Practolol

The proposed withdrawal by Imperial Chemical Industries of practolol injection will remove an important strand from anaesthetists' therapeutic safety net. It is a drug which is presented conveniently, often effective in very low dosage against the types of dysrrhythmia frequently encountered in excessive sympathetic stimulation of the myocardium. Its intrinsic sympathomimetic activity avoids the hypotensive synergism with anaesthetic agents which would be a problem with drugs like propranolol. If there were an alternative beta blocker with a similar presentation and characteristics, the withdrawal of practolol might be acceptable. However, none springs to mind. Those colleagues who find practolol to be useful might themselves write to ICI and express their views.

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Anaesthetic literature

This section of *Anaesthetic literature* contains references taken from *Current Contents—Life Sciences* for April 1988. The The Journals which may be consulted when *Anaesthetic literature* is compiled are those listed in *Current Contents—Life Sciences*, published by the Institute of Scientific Information, Philadelphia, Pennsylvania, USA.

Abdominal surgery

Intestinal anaphylaxis: rapid changes in mucosal ion transport and morphology. Baron DA, Baird AW *et al. Americal Journal of Physiology* 1988; **254:** G307.

Mucosal innervation and control of water and ion transport in the intestine. Keast JR, In: Baker PF *et al.* eds. *Reviews of physiology, biochemistry and pharmacology, Vol. 109.* Basel: Springer-Verlag, 1987: 1.

Effects of somatostatin on splanchnic hemodynamics and plasma glucagon in portal hypertensive rats. Kravetz D, Bosch J *et al. American Journal of Physiology* 1988; **254:** G322.

New insights on the mechanism of the alcohol-induced increase in portal blood flow. Orrego H, Carmichael FJ, Israel Y. *Canadian Journal of Physiology and Pharmacology* 1988; **66:** 1.

Relationship of postoperative septic complications and blood transfusions in patients with Crohn's disease. Tartter PI, Driefuss RM *et al. American Journal of Surgery* 1988; **155:** 43.

Pharmacology

Adrenergic drugs and their antagonists

Differentiation of beta 1- and beta 2-adrenoceptor-mediated effects in humans. Brodde OE, Daul A *et al. American Journal of Physiology* 1988; **254:** H199.

Agonist profile of ergometrine (ergonovine) on a population of post-synaptic alpha-adrenoceptors. Gibson A, Carvajal A. *Journal of Pharmacy and Pharmacology* 1988; **40:** 137.

Effect of beta-blocking agents on hemorheological properties. Heilmann L, Miller B. *Clinical Hemorheology* 1988; **8:** 31.

Presynaptic interactions between acetylcholine and adrenergic antagonists on norepinephrine release. Kalsner S, Quillan M. *Journal of Pharmacology and Experimental Therapeutics* 1988; **244:** 879.

Clinical pharmacokinetics of encainide. Roden DM, Woosley RL *Clinical Pharmacokinetics* 1988; **14:** 141.

The racemic metoprolol H2-antagonist interaction. Toon S, Davidson EM. *Clinical Pharmacology and Therapeutics* 1988; **43:** 283.

Anaesthetic agents

Extrahepatic sites of metabolism of halothane in the rat. Ghantous H, Lofberg B *et al. Pharmacology and Toxicology* 1988; **62:** 135.

Halogenated vapor anesthetics adversely influence edrophonium reversal. Gyermek I. *International Journal of Clinical Pharmacology Therapy and Toxicology* 1988; **26:** 75.

Propofol, the newest induction agent of anesthesia. Kanto JH. *International Journal of Clinical Pharmacology Therapy and Toxicology* 1988; **26:** 41.

Brotizolam: a review of its pharmacodynamic and pharmacokinetic properties, and therapeutic efficacy as an hypnotic. Langley MS, Clissold SP. *Drugs* 1988; **35:** 104.

An electrographic characterization of ketamine-induced linguopharyngeal motor activity. Marco LA, Reed TF *et al. Clinical Neuropharmacology* 1988; **11:** 141.

Lorazepam conjugation is unimpaired in burn trauma. Martyn J, Greenblatt DJ. *Clinical Pharmacology and Therapeutics* 1988; **43:** 250.

Serum doxapram and respiratory neuromuscular drive in normal man. Okubo S, Konno K *et al. European Journal of Clinical Pharmacology* 1988; **34:** 55.

Clinical pharmacokinetics of midazolam in intensive care patients, a wide interpatient variability? Oldenhof H, De Jong M *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 263.

Relation of sedation and amnesia to plasma concentrations of midazolam in surgical patients. Person MP, Nilsson A, Hartvig P *Clinical Pharmacology and Therapeutics* 1988; **43:** 324.

Structural factors governing agonist and antagonist activity in the GABA system. Pooler GW, Steward EG. *Biochemical Pharmacology* 1988; **37:** 943.

The effect of chronic diazepam and medazepam treatment on the number and affinity of muscarinic receptors in different rat brain structures. Popova J, Petkov VV, Tokuschieva L. *General Pharmacology* 1988; **19:** 227.

Ketamine protects acetylcholinesterase against in vitro inhibition by sarin. Puu G. *Biochemical Pharmacology* 1988; **37:** 969.

Analgesic agents

Naltrexone: a review of its pharmacodynamic and pharmacokinetic properties and therapeutic efficacy in the management of opioid dependence. Gonzalez JP, Brogden RN. *Drugs* 1988; **35:** 192.

Patient controlled analgesia and urinary retention. Hodsman NBA, Kenny GNC, McArdle CS. *British Journal of Surgery* 1988; **75:** 212.

Effect of ethanol on serum electrolytes and osmolality. Mahboob T, Haleem MA. *Life Sciences* 1988; **42:** 1507.

Antifibrillatory action of the narcotic agonist fentanyl. Saini V, Carr DB *et al. American Heart Journal* 1988; **115:** 598.

Muscle relaxants

Effects of some mono- and bisquaternary ammonium compounds on the reactivatability of soman-inhibited human acetylcholinesterase in vitro. Hallek M, Szinicz L. *Biochemical Pharmacology* 1988; **37:** 819.

Contractile properties of cat skeletal muscle after repetitive stimulation. Hatcher DD, Luff AR. *Journal of Applied Physiology* 1988; **64:** 502.

Presynaptic effects of d-tubocurarine on neurotransmitter release at the neuromuscular junction of the frog. Matzner H, Pernas H, Parnas I. *Journal of Physiology* 1988; **398:** 109.

An in vitro electromyography chamber to monitor neuromuscular function. Pagala MKD. *Journal of Electrophysiological Techniques* 1987; **14:** 197.

The collator of this section is Dr L. Kaufman, MD, FFARCS, Anaesthetic Office, The Rayne Institute, University College, University Street, London WC1E 6JJ. Dr Kaufman is prepared to provide on request, and at a modest charge, a new additional service to our readers. References from January 1984 have been entered on data base. The data are held on Dbase II, cpm 86 and on Dbase III, MsDos and are available on disc, together with a program providing search facilities. Enquiries direct to Dr Kaufman at the above address please.

Muscular contraction. Huxley A. *Annual Review of Physiology* 1988; **50:** 1.

Lambert-Eaton myasthenic syndrome involving the diaphragm. Wilcox PG, Morrison NJ *et al. Chest* 1988; **93:** 604.

Other drugs

Adverse reactions to the non-drug constituents of nebuliser solutions. Beasley R, Rafferty P, Holgate ST. *British Journal of Clinical Pharmacology* 1988; **25:** 283.

Effects of the dopamine antagonists haloperidol and domperidone on the normoxic ventilatory response to CO_2 in cats. Berkenbosch A, Olievier CN, Degoede J. *European Journal of Physiology* 1988; **411:** 278.

Nephrotoxicity of high-osmolality and low-osmolality contrast media. Jevnikar AM, Finnie KJC *et al. Nephron* 1988; **48:** 300.

Intratracheal drugs. Leading Article *Lancet* 1988; **1:** 743.

Inhibitory effects of ranitidine on flushing and serum serotonin concentrations in carcinoid syndrome. Noppen M, Jacobs A *et al. British Medical Journal* 1988; **296:** 682.

Cytochrome P450: molecular architecture, mechanism, and prospects for rational inhibitor design. Poulos TL. *Pharmaceutical Research* 1988; **5:** 67.

Comparison of the effects of metoclopramide on sympathetic and muscarinic responses after pretreatment with atropine and pirenzepine. Syvalahti EKG, Ylitalo A *et al. International Journal of Clinical Pharmacology Therapy and Toxicology* 1988; **26:** 16.

Apparatus

Bias and precision of pulse oximeters and arterial oximeters. Nickerson BG, Sarkisian C, Tremper K. *Chest* 1988; **93:** 515.

The accuracy of pulse oximeters. A comparative clinical evaluation of five pulse oximeters. Taylor MB, Whitwam JG *Anaesthesia* 1988; **43:** 229.

Complications

Death and brain death: a new formulation for Canadian medicine. Canadian Congress Committee on Brain Death. *Canadian Medical Association Journal* 1988; **138:** 405.

Adverse drug reactions and drug non-compliance as primary causes of admission to a cardiology department. Davidsen F, Haghfelt T *et al. European Journal of Clinical Pharmacology* 1988; **34:** 83.

Possible mechanisms of acute pancreatitis induced by ethanol. Harvey MH, Cates MC, Reber HA. *American Journal of Surgery* 1988; **155:** 49.

Pentopril-cimetidine interaction caused by a reduction in hepatic blood flow. Kochak GM, Rakhit A *et al. Journal of Clinical Pharmacology* 1988; **28:** 222.

Drug reactions: unravelling idiosyncrasy. Lee RE. *Canadian Medical Association Journal* 1988; **138:** 409.

Bleomycin causes alveolar macrophages from cigarette smokers to release hydrogen peroxide. Lower EE, Strohofer S, Baughman RP. *American Journal of the Medical Sciences* 1988; **295:** 193.

Sudden cardiac death in obesity and hypertension. Leading Article. *Lancet* 1988; **1:** 628.

Hypomagnesemia, hypocalcemia, and toxic-shock syndrome. A case report. Rudick JH, Sheehan JP. *Magnesium* 1987; **6:** 325.

General anaesthetic procedures

The stress response to induced hypotension for cerebral aneurysm surgery: a comparison of two hypotensive techniques. Macnab MSP, Manninen PH *et al. Canadian Journal of Anaesthesia* 1988; **35:** 111.

Effect of surgical stimulation on the auditory evoked response. Thornton C, Konieczko *et al. British Journal of Anaesthesia* 1988; **60:** 372.

General interest

Measurement of catecholamines, met-enkephalin, somatostatin and substance P-like immunoreactivities in 12 human pheochromocytomas. Baldi E, de Feo ML *et al. Journal of Endocrinological Investigation* 1988; **11:** 133.

Current concepts—immunology: monocytes and macrophages. Johnston RB Jr. *New England Journal of Medicine* 1988; **318:** 747.

Myocardial fuel and energy balance, acute ischemia and diabetes. McDaniel HG, Jenkins RL *et al. American Journal of the Medical Sciences* 1988; **295:** 207.

Endotoxaemia: an early predictor of septicaemia in febrile patients. Van Deventer SJH, Buller HR *et al. Lancet* 1988; **1:** 605.

Local analgesia

Lidocaine concentrations in bronchoscopic specimens. Strange C, Barbarash RA, Heffner JE. *Chest* 1988; **93:** 547.

Spinal and epidural analgesia

Effects of spinal anesthesia on response to main pulmonary arterial distension. Pearl RG, McLean RF, Rosenthal MH. *Journal of Applied Physiology* 1988; **64:** 742.

Ventilatory responses to hypercapnia during bupivacaine spinal anesthesia. Steinbrook RK, Concepcion M, Topulos GP. *Anesthesia and Analgesia* 1988; **67:** 247.

Spinal opioids

Naloxone infusion after prophylactic epidural morphine: effects on incidence of postoperative side-effects and quality of analgesia. Gowan JD, Hurtig JB *et al. Canadian Journal of Anaesthesia* 1988; **35:** 143.

The pharmacokinetics of intradural morphine in major abdominal surgery. Ionescu TI, Drost RH *et al. Clinical Pharmacokinetics* 1988; **14:** 178.

K-opioid agonists produce antinociception after i.v. and i.c.v. but not intrathecal administration in rat. Leighton GE, Rodriguez RE *et al. British Journal of Pharmacology* 1988; **93:** 553.

Continuous epidural morphine analgesia after radical operations upon the pelvis. Planner RS, Cowie RW, Babarczy AS. *Surgery—Gynecology and Obstetrics* 1988; **166:** 229.

Epidural bupivacaine and morphine plus systemic indomethacin eliminates pain but not systemic response and convalescence after cholecystectomy. Schulze S, Roikjaer O *et al. Surgery* 1988; **103:** 321.

Patient-controlled analgesia with extradural morphine or pethidine. Sjostrom S, Hartvig D, Tamsen A. *British Journal of Anaesthesia* 1988; **60:** 358.

Postoperative effects of intrathecal morphine in coronary artery bypass surgery. Vanstrum GS, Bjornson KM, Ilko R. *Anesthesia and Analgesia* 1988; **67:** 261.

Obstetric anaesthesia and analgesia

Clinical indications for pulmonary artery catheterization in the patient with severe preeclampsia. Clark SL, Cotton DB. *American Journal of Obstetrics and Gynecology* 1988; **158:** 453.

Hemodynamic profile of severe pregnancy-induced hypertension. Cotton DB, Lee W *et al. American Journal of Obstetrics and Gynecology* 1988; **158:** 523.

Epidural analgesia with a bupivacaine-fentanyl mixture in obstetrics: comparison of repeated injections and continuous infusion. D'Athis FD, Macheboeuf M *et al. Canadian Journal of Anaesthesia* 1988; **35:** 116.

Placental-type plasminogen activator inhibitor in preeclampsia. De boer K, Lecander I *et al. American Journal of Obstetrics and Gynecology* 1988; **158:** 518.

Placental amino acid uptake in normal and complicated pregnancies. Dicke JM, Henderson GI. *American Journal of the Medical Sciences* 1988; **295:** 223.

Fetal endoxin and pregnancy complication. Goodlin RC. *American Journal of Obstetrics and Gynecology* 1988; **158:** 529.

Evaluation of arterial oxygen saturation in pregnant patients and their newborns. Porter KB, Goldhamer R *et al. Obstetrics and Gynecology* 1988; **71:** 354.

Clinicopathological study of neurological complications due to hypertensive disorders of pregnancy. Richards A, Graham D, Bullock R. *Journal of Neurology, Neurosurgery and Psychiatry* 1988; **51:** 416.

Fetal heart rate beat-to-beat variability in uncomplicated labor. Zimmer EZ, Divon MY, Vadasz A. *Gynecologic and Obstetric Investigation* 1988; **25:** 80.

Maternal whole blood viscosity in pregnancy hypertension. Zondervan HA, Oosting J *et al. Gynecologic and obstetric investigation* 1988; **25:** 83.

Paediatric anaesthesia and intensive care

Emergency drug doses for infants and children. American Academy of Pediatrics *Pediatrics* 1988; **81:** 462.

Does halothane anaesthesia decrease the metabolic and endocrine stress responses of newborn infants undergoing operation? Anand KJS, Sippell WG *et al. British Medical Journal* 1988; **296;** 668.

Negative pressures used for delivery room neonatal resuscitation. Ballard JL, Farley AJ *et al. Journal of Pediatrics* 1988; **112:** 478.

Control of alveolar surfactant in rats at rest and during prolonged hyperpnoea: pharmacological evidence for two tissue pools of surfactant. Barr HA, Nicholas TE, Power JHT. *British Journal of Pharmacology* 1988; **93:** 473.

Pharmacokinetics of doxapram in idiopathic apnea of prematurity. Beaudry MA, Bradley JM *et al. Developmental Pharmacology and Therapeutics* 1988; **11:** 65.

Umbilical cord acid base changes associated with perinatal cardiac failure. Brar HS, Wong MK *et al. American Journal of Obstetrics and Gynecology* 1988; **158:** 511.

Early neonatal drug utilization in preterm newborns in neonatal intensive care units. Italian Collaborative Group On Preterm Delivery. *Developmental Pharmacology and Therapeutics* 1988; **11:** 1.

Sleep effect of rectal methohexitone (10 mg/kg) in children premidicated for anaesthesia. Karhunen U. *Developmental Pharmacology and Therapeutics* 1988; **11:** 92.

Monitoring for central apnoea in infancy-limitations of single channel recordings. MacFadyen UM, Borthwick G *et al. Archives of Disease in Childhood* 1988; **63;** 282.

The nature of pain. McGrath PJ, Unruh AM In: McGrath PJ, Unruh AM. *Pain in children and adolescents.* Amsterdam: Elsevier, 1987: 47.

Perioperative and postoperative pain. McGrath PJ, Unruh AM. In: McGrath PJ, Unruh AM. *Pain in children and adolescents.* Amsterdam: Elsevier, 1987: 105.

Normal range of fetal transcutaneous carbon dioxide tension during labour. Nickelsen C, Weber T. *British Journal of Obstetrics and Gynaecology* 1988; **95:** 257.

Respiratory origin of fluctuations in arterial blood pressure in premature infants with respiratory distress syndrome. Periman J, Thach B. *Pediatrics* 1988; **81:** 395.

Time course of adaptation to hypoxia in newborn rats. Piazza T, Lauzon AM, Mortola JP. *Canadian Journal of Physiology and Pharmacology* 1988; **66:** 152.

Adult respiratory distress syndrome in pediatric patients. 2. Management. Royall J, Levin DL. *Journal of Pediatrics* 1988; **112:** 335.

Measurement of tidal volume during high frequency ventilation by impedance plethysmography. Sandberg KL, Lindstrom DP *et al. Pediatric Research* 1988; **23:** 253.

Variable arginine vasopressin levels in neonatal congestive heart failure. Stewart JM, Zeballos GA *et al. Journal of the American College of Cardiology* 1988; **11:** 645.

Cardiovascular system

Physiology

Evaluation of baroreceptor reflex by blood pressure monitoring in unanesthetized cats. Bertinieri G, Di Rienzo M *et al. American Journal of Physiology* 1988; **254:** H377.

Effect of amiloride on regulatory mechanisms of vascular smooth muscle contraction. Chaterjee M, Chiu PJS *et al. Biochemical Pharmacology* 1988; **37:** 813.

Erythropoietin: the developing story. Cotes PM. *British Medical Journal* 1988; **296:** 805.

Assessing stenosis severity—coronary flow reserve, collateral function, quantitative coronary arteriography. A review and analysis. Demer L, Gould KL, Kirkeeide R. *Progress in Cardiovascular Diseases* 1988; **30:** 307.

Plasma concentrations of atrial natriuretic peptide in patients with artificial and transplanted hearts. Deray G, Maistre G *et al. European Journal of Clinical Pharmacology* 1988; **34:** 91.

Nocturnal fluctuations of plasma atrial natriuretic peptide in normotensive and hypertensive men. Follenius M, Brandenberger G, Simon C. *Life Sciences* 1988; **42:** 1635.

The mode of action of heparin in plasma. Hemker HC. In: Verstraete M *et al.*, eds. *Thrombosis and haemostasis.* Louvain: Leuven University Press, 1987: 17.

Mechanism of death and prevalence of myocardial ischemic symptoms in the terminal event after acute myocardial infarction. Marcus FI, Cobb LA *et al. American Journal of Cardiology* 1988; **61:** 8.

Stretch-induced reduction in atrial content of natriuretic factor is locally mediated. Meikle ADS, Kaufman S. *American Journal of Physiology* 1988; **254:** R284.

Effects of hemodilution in skin microcirculation. Mirhashemi S, Breit GA *et al. American Journal of Physiology* 1988; **254:** H411.

Low dose infusion of atrial natriuretic peptide causes salt and water excretion in normal man. Morice A, Pepke-Zaba J *et al. Clinical Science* 1988; **74:** 359.

Septicemia and the vessel wall. Mullerberghaus G. In: Verstraete M *et al.*, eds. *Thrombosis and haemostasis.* Louvain: Leuven University Press, 1987: 619.

Left ventricular performance in canine endotoxin shock. Papadakis EJ, Abel FL. *Circulatory Shock* 1988; **24:** 123.

The effects of hypoxemia on cardiac output: a dose-response curve. Phillips BA, McConnell JW, Smith MD. *Chest* 1988; **93:** 471.

Cellular oxygen metabolism during sepsis and shock. Rackow EC, Astiz ME, Weil MH. *Journal of the American Medical Association* 1988; **259:** 1989.

Why does vasodilation occur during syncope? Robinson BJ, Johnson RH. *Clinical Science* 1988; **74:** 347.

Role of adrenal medulla in hemodynamic response to hemorrhage and naloxone. Schadt JC, Gaddis RR. *American Journal of Physiology* 1988; **254:** R559.

Minireview: A role of calcium in altered sodium ion transport of hypertensives? Shiffman FH, Bose R. *Life Sciences* 1988; **42:** 1573.

Effects of l-epinephrine on hemodynamics and cardiac function in coronary disease: dose-response studies. Sung BH, Robinson C *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 308.

Potassium and myoglobin release and ST and QRS vector changes during acute myocardial infarction. Sylven C, Sederholm M. *Clinical Physiology* 1988; **8:** 129.

Atrial natriuretic peptide in volume expansion-induced natriuresis in man. Tulassay T, Ruskoaho H *et al.* Hypertension 1988; **10:** 363.

Cardiovascular system

Treatment and medication

Atrial natriuretic peptide during acute treatment of congestive heart failure. Berglund H, Bevegard S *et al. Clinical Physiology* 1988; **8:** 155.

Hemorheologic integrity after intraoperative blood transfusion. Berling C, Lacombe C *et al. Clinical Hemorheology* 1988; **8:** 81.

Severity of anaemia and operative mortality and morbidity. Carson JL, Poses RM *et al. Lancet* 1988; **1:** 727.

The impact of distal aortic perfusion and somatosensory evoked potential monitoring on prevention of paraplegia after aortic aneurysm operation. Crawford ES, Mizrahi EM *et al. Journal of Thoracic and Cardiovascular Surgery* 1988; **95:** 357.

Combination of calcium channel blocker and thrombolytic therapy in acute myocardial infarction. Erbel R, Pop T *et al. American Heart Journal* 1988; **115:** 529.

Alpha-adrenergic blockers. Frishman WH, Charlap S *Medical Clinics of North America* 1988; **72:** 427.

Ultra-short-acting beta-adrenergic blockers. Frishman WH, Murthy VS, Strom JA. *Medical Clinics of North America* 1988; **72:** 359.

Drugs interfering with platelet functions—mechanisms and clinical relevance. Fuster V, Badimon L *et al.* In: Verstraete M *et al.*, eds. *Thrombosis and haemostasis. Louvain:* Leuven University Press, 1987: 349.

The effects of antihypertensive drugs on glucose intolerance in hypertensive nondiabetics and diabetics. Houston MC. *American Heart Journal* 1988; **115:** 640.

Post-transfusional vs sporadic non-A, non-B chronic hepatitis. A clinico-pathological and evolutive study. Jove J, Sanchez-Tapias JM *et al. Liver* 1988; **8:** 42.

Circulating cardiac myosin light chains in patients with angina at rest—identification of a high risk subgroup. Katus HA, Diederich KW *et al. Journal of the American College of Cardiology* 1988; **11:** 487.

Role of thromboxane A2 in the hypotensive effect of captopril in essential hypertension. Kudo K, Abe K *et al. Hypertension* 1988; **11:** 147.

Newer antiarrhythmic drugs. Michelson EL, Dreifus LS. *Medical Clinics of North America* 1988; **72:** 275.

Recent advances in the management of venous thromboembolism. Mohr DN, Ryu JH *et al. Mayo Clinic Proceedings* 1988; **63:** 281.

Effects of phentolamine and atropine on angina pectoris induced by handgrip test in patients with variant angina. Morikami Y, Yasue H *et al. American Journal of Cardiology* 1988; **61:** 71.

New antiarrhythmic drugs. Nestico PF, Morganroth J, Horowitz LN. *Drugs* 1988; **35:** 286.

Pharmacokinetics of a new angiotensin I converting enzyme inhibitor (delapril) in patients with deteriorated kidney function and in normal control subjects. Onoyama K, Nanishi F *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 242.

Calcium, the renin-aldosterone system, and the hypotensive response to nifedipine. Resnick LM, Nicholson JP, Laragh JH. *Hypertension* 1987; **10:** 254.

Angiotensin-converting enzyme inhibitors. Rotmensch HH, Vlasses PH, Ferguson RK. *Medical Clinics of North America* 1988; **72:** 399.

Use of hemodilution in patients with arteriopathy: effects on hemorheological parameters and platelet function. Voisin PH, Chevreaud C *et al. Clinical Hemorheology* 1988; **8:** 47.

Respiration

Physiology

Transverse abdominis length changes during eupnea, hypercapnia, and airway occlusion. Arnold JS, Haxhiu MA *et al. Journal of Applied Physiology* 1988; **64:** 658.

Failure of neuromuscular propagation during human maximal voluntary contraction. Bellemare F, Garzaniti N. *Journal of Applied Physiology* 1988; **64:** 1084.

Ventilatory muscle training in the elderly. Belman MJ, Gaesser GA. *Journal of Applied Physiology* 1988; **64:** 899.

Lung macrophages—how many kinds are there—what do they do? Brain JD. *American Review of Respiratory Disease* 1988; **137:** 507.

Possible mechanisms of periodic breathing during sleep. Chapman KR, Bruce EN *et al. Journal of Applied Physiology* 1988; **64:** 1000.

Pulmonary microvascular permeability to fluid and macromolecules. Drake RE, Laine GA. *Journal of Applied Physiology* 1988; **64:** 487.

Oxygen and carbon isotopic compositions of gases respired by humans. Epstein S, Zeiri L. *Proceedings of the National Academy of Sciences of the United States of America* 1988; **85:** 1727.

Dissociation between diaphragmatic and rib cage muscle fatigue. Fitting JW, Bradley TD *et al. Journal of Applied Physiology* 1988; **64:** 959.

Effect of body posture on spatial distribution of pulmonary blood flow. Hakim TS, Dean GW, Lisbona R. *Journal of Applied Physiology* 1988; **64:** 1160.

Hypoxic vasoconstriction in blood and plasma perfused lungs. Hakim TS, Malik AB. *Respiration Physiology* 1988; **72:** 109.

Genioglossus and breathing responses to airway occlusion: effect of sleep and route of occlusion. Issa FG, Edwards P *et al. Journal of Applied Physiology* 1988; **64:** 543.

Effects of lung volume, bronchoconstriction, and cigarette smoke on morphometric airway dimensions. James AL, Pare PD, Hogg JC. *Journal of Applied Physiology* 1988; **64:** 913.

Dyspnea and diaphragmatic fatigue in patients with chronic obstructive pulmonary disease—responses to theophylline. Kongragunta VR, Druz WS, Sharp JT. *American Review of Respiratory Disease* 1988; **137:** 662.

Low frequency diaphragmatic fatigue in spontaneously breathing humans. Levine S, Henson D. *Journal of Applied Physiology* 1988; **64:** 672.

Head position modifies upper airway resistance in men. Liistro G, Stanescu D *et al. Journal of Applied Physiology* 1988; **64:** 1285.

Development of pulmonary vascular response to oxygen. Morin FC III, Egan EA *et al. American Journal of Physiology* 1988; **254:** H542.

Pulmonary hypertension from chronic pulmonary thromboembolism. Rich S, Levitsky S, Brundage BH. *Annals of Internal Medicine* 1988; **108:** 425.

Pulmonary function tests cannot predict exercise-induced hypoxemia in chronic obstructive pulmonary disease. Ries AL, Farrow JT, Clausen JL. *Chest* 1988; **93:** 454.

The Bohr effect. Riggs AF. *Annual Review of Physiology* 1988; **50:** 181.

Work of breathing and airway occlusion pressure during assist-mode mechanical ventilation. Sassoon CSH, Mahutte CK *et al. Chest.* 1988; **93:** 571.

Induction of upper airway occlusion in sleeping individuals with subatmospheric nasal pressure. Schwartz AR, Smith PL *et al. Journal of Applied Physiology* 1988; **64:** 535.

The propulsion of mucus by cilia. Sleigh MA, Blake JR, Liron N. *American Review of Respiratory Disease* 1988; **137:** 726.

Ventilatory effects of potassium during hyperoxia, normoxia and hypoxia in anaesthetized cats. Sneyd JR, Linton RAF, Band DM. *Respiration Physiology* 1988; **72:** 59.

The osmolality of nasal secretions increases when inflammatory mediators are released in response to inhalation of cold dry air. Togias AG, Proud D *et al. American Review of Respiratory Disease* 1988; **137:** 625.

Oxygen cost of breathing in postoperative patients—pressure support ventilation vs continuous positive airway pressure. Viale JP, Annat GJ *et al. Chest* 1988; **93;** 506.

Sleep and the ventilatory response to resistive loading in normal men. Wiegand L, Zwillich CW, White DP. *Journal of Applied Physiology* 1988; **64:** 1186.

Treatment and medication

Chronic obstructive pulmonary disease. Anthonisen NR. *Canadian Medical Association Journal* 1988; **138:** 503.

PAF antagonists: their potential therapeutic role in asthma. Chung KF, Barnes PJ. *Drugs* 1988; **35:** 93.

Mechanical ventilation after marrow transplantation—risk factors and clinical outcome. Crawford SW, Schwartz DA *et al. American Review of Respiratory Disease* 1988; **137:** 682.

Pressure support compensation for inspiratory work due to endotracheal tubes and demand continuous positive airway pressure. Fiastro JF, Habib MP, Quan SF. *Chest* 1988; **93:** 499.

Clinical efficacy of high frequency jet ventilation during extracorporeal shock wave lithotripsy of renal and ureteral calculi. Warner MA, Warner ME *et al. Journal of Urology* 1988; **139:** 486.

Central nervous system

Physiology

The cranial arachnoid and pia mater in man: anatomical and ultrastructural observations. Alcolado R, Weller RO *et al. Neuropathology and Applied Neurobiology* 1988; **14:** 1.

Respiration during sleep in Huntington's chorea. Bollen EL, Den Heijer JC *et al. Journal of the Neurological Sciences* 1988; **84:** 63.

Neurotransmitter systems and epilepsy—an overview. Dailey JW, Jobe PC. In: Jobe PC, Laird HE eds. *Neurotransmitters and epilepsy.* Clifton: Humana Press, 1987: 1.

Beta-adrenergic control of brain uptake of large neutral amino acids. Eriksson T, Carlsson A. *Life Sciences* 1988; **42:** 1583.

Plasma adenosine and hypoxemia in patients with sleep apnea. Findley LJ, Boykin M *et al. Journal of Applied Physiology* 1988; **64:** 556.

Neurotransmitters in human epilepsy. Kresch MJ, Shaywitz BA *et al.* In: Jobe PC, Laird HE eds. *Neurotransmitters and epilepsy.* Clifton: Humana Press, 1987: 321.

Effects of vasodilatation and acidosis on the blood-brain barrier. Mayhan WG, Faraci FM *et al. Microvascular Research* 1988; **35:** 179.

Mechanisms of brain damage in focal cerebral ischemia. Nedergaard M. *Acta Neurologica Scandinavica* 1988; **77:** 81.

Changes in central GABAergic function following acute and repeated stress. Otero Losada ME. *British Journal of Pharmacology* 1988; **93:** 483.

Hypoglycemia, brain metabolism, and brain damage. Siesjo BK. *Diabetes/Metabolism Reviews* 1988; **4:** 113.

Endorphin mechanisms are responsible for the beneficial effects of opioid antagonists on cerebral function during relative cerebral ischaemia in rats. Skarphedinsson JO, Thoren P. *Acta Physiologica Scandinavica* 1988; **132:** 281.

Upper airway pressure-flow relationships in obstructive sleep apnea. Smith PL, Wise RA *et al. Journal of Applied Physiology* 1988; **64:** 789.

The physiological function of nerve growth factor in the central nervous system–comparison with the periphery. Thoenen H, Bandtlow C, Heumann R. In: Baker PF *et al.*, eds. *Reviews of Physiology, biochemistry and pharmacology, Vol 109.* Basel: Springer-Verlag, 1987: 145.

Treatment and medication

Monoamines, depression and antidepressant drugs. Checkley S. *Pharmacopsychiatry* 1988; **21:** 6.

Seizures induced by convulsant drugs. Faingold CL. In: Jobe PC, Laird HE. eds, *Neurotransmitters and Epilepsy.* Clifton: Humana Press, 1987: 215.

A critical review of EMG-controlled electrical stimulation in paraplegics. Graupe D, Kohn KH. *CRC Critical Reviews in Biomedical Engineering* 1988; **15:** 187.

Outcome from coma after cardiopulmonary resuscitation—relation to seizures and myoclonus. Krumholz A, Stern BJ, Weiss HD. *Neurology* 1988; **38:** 401.

Clinical and neuropathologic assessment of severity in Huntingtons disease. Myers RH, Vonsattel JP *et al. Neurology* 1988; **38:** 341.

Cerebral blood flow, vasoreactivity, and oxygen consumption during barbiturate therapy in severe traumatic brain lesions. Nordstrom CH, Messeter K *et al. Journal of Neurosurgery* 1988; **68:** 424.

Admission glucose level in relation to mortality and morbidity outcome in 252 stroke patients. Woo E, Chan YW *et al. Stroke* 1988; **19:** 185.

Endocrine and metabolic

Physiology

An immunochemical analysis of oxytocin and vasopressin prohormone processing in vivo. Altstein M, Whitnall MH *et al. Peptides* 1988; **9:** 87.

Vasoregulatory hormones and the hyperfiltration of diabetes. Bank N, Lahorra MAG *et al. American Journal of Physiology* 1988; **254:** F202.

Oxytocin response to insulin-induced hypoglycemia in obese subjects. Coiro V, Passeri M *et al. Journal of Endocrinological Investigation* 1988; **11:** 125.

Atrial natriuretic peptides: the role of phenylalanine on biological activity. Craven TG, Kem DC *et al. Endocrinology* 1988; **122:** 826.

Potassium homeostasis in liver cirrhosis. Decaux G, Soupart A *et al. Archives of Internal Medicine* 1988; **148:** 547.

Plasma beta-endorphin resistance to dexamethasone suppression in obese patients. Facchinetti F, Giobannini C *et al. Journal of Endocrinological Investigation* 1988; **11:** 119.

Increased fetal secretion of ACTH and cortisol by arginine vasopressin. Faucher DJ, Laptook AR *et al. American Journal of Physiology* 1988; **254:** R410.

Vasopressin but not oxytocin enhances cortical arousal: an integrative hypothesis on behavioural effects of neurohypophyseal hormones. Fehm-wolfsdort G, Bachholz G *et al. Psychopharmacology* 1988; **94:** 496.

Effects of incremental infusions of arginine vasopressin on adrenocorticotropin and cortisol secretion in man. Hensen J, Hader O *et al. Journal of Clinical Endocrinology and Metabolism* 1988; **66:** 668.

Effect of atrial natriuretic factor on renal function in rats with nephrotic syndrome. Hildebrandt DA, Banks RO. *American Journal of Physiology* 1988; **254:** F210.

Hypotensive and bradycardiac effects of centrally administered vasopressin in stroke-prone spontaneously hypertensive rats. Imai Y, Abe K *et al. Hypertension* 1987; **10:** 346.

Effect of increased surface tension and assisted ventilation on 99mTc-DTPA clearance. Jefferies AL, Kawano T *et al. Journal of Applied Physiology* 1988; **64:** 562.

Antagonists of the antidiuretic activity of vasopressin. Kinter LB, Huffman WF, Stassen FL. *American Journal of Physiology* 1988; **254:** F165.

Hormonal response to exercise in humans: influence of hypoxia and physical training. Kjaer M, Bangsbo J *et al. American Journal of Physiology* 1988; **254:** R192.

The classification of 5-hydroxytryptamine receptors. Leff P, Martin GR. *Medicinal Research Reviews* 1988; **8:** 187.

Effect of physical exercise on sensitivity and responsiveness to insulin in humans. Mikines KJ, Sonne B *et al. American Journal of Physiology* 1988; **254:** E248.

Biological and immunological characterization of corticotropin-releasing activity in the bovine adrenal medulla. Minamino N, Uehara A, Arimura A. *Peptides* 1988; **9:** 37.

Responses of plasma oxytocin and arginine vasopressin to nausea induced by apomorphine and ipecacuanha. Nussey SS, Hawthorn J *et al. Clinical Endocrinology* 1988; **28:** 297.

The response of plasma oxytocin to surgical stress. Nussey SS, Page SR *et al. Clinical Endocrinology* 1988; **28:** 277.

Endocrine responses to acute stress in castrated rams—no increase in oxytocin but evidence for an inverse relationship between cortisol and vasopressin. Parrott RF, Thornton SN, Robinson JE. *Acta Endocrinologica* 1988; **117:** 381.

Renin, ACTH, and aldosterone during acute hypercapnia and hypoxia in conscious rats. Raff H, Roarty TP. *American Journal of Physiology* 1988; **254:** R431.

Mechanism of action of hormones in regulation of adenylate cyclase. Reyldesmars FJ. *Gastroenterologie Clinique et Biologique* 1988; **12:** 149.

Ventricular receptors stimulate vasopressin release during hemorrhage. Wang BC, Flora-Ginter G *et al. American Journal of Physiology* 1988; **254:** R204.

Weight loss with physiologic impairment: a basic indicator of surgical risk. Windsor JA, Hill GL. *Annals of Surgery* 1988; **207:** 290.

Insulin response of components of whole-body and muscle carbohydrate metabolism in humans. Young AA, Bogardus C *et al. American Journal of Physiology* 1988; **254:** E231.

Treatment and medication

Hemodynamic and coagulation responses to 1-desamino (8-D-arginine) vasopressin in patients with congenital nephrogenic diabetes insipidus. Bichet DG, Razi M *et al. New England Journal of Medicine* 1988; **318:** 881.

Development of acute tolerance to bumetanide: constant-rate infusion studies. Cook JA, Smith DE. *Pharmaceutical Research* 1988; **5:** 86.

Overt glucocorticoid excess due to inhaled corticosteroid therapy. Hollman GA, Allen DB. *Pediatrics* 1988; **81:** 452.

Insulin resistance and hyperinsulinemia in patients with thalassemia major treated by hypertransfusion. Merkel PA, Simonson DC *et al. New England Journal of Medicine* 1988; **318:** 809.

Glyburide or insulin for metabolic control in non-insulin-dependent diabetes mellitus: a randomized, double-blind study. Nathan DM, Roussell A, Godine JE. *Annals of Internal Medicine* 1988; **108:** 334.

Metabolic intervention in surgical patients; an assessment of the effect of somatostatin, ranitidine, naloxone, diclophenac, dipyridamole, or salbutamol infusion on energy and protein kinetics in surgical patients using stable and nadioisotopes. Shaw JHF, Wolfe RR. *Annals of Surgery* 1988; **207:** 274.

Other

Physiology

Large volume gastroesophageal reflux: a rationale for risk reduction in the perioperative period. HARDY JF. *Canadian Journal of Anaesthesia* 1988; **35**: 162.

Smooth muscle intracellular pH: measurement, regulation, and function. WRAY S. *American Journal of Physiology* 1988; **254**: C213.

Anaesthesia, 1988, Volume 43, pages 721–725

The Annual Conference of Linkmen of the Association of Anaesthetists of Great Britain and Ireland, 1987

The twelfth Annual Conference of Linkmen was held at the Octagon Centre, Sheffield, on Wednesday 9 September 1987.

The President, Professor M. Rosen, was in the chair throughout the meeting. He welcomed the 130 Linkmen present, thanked them for their attendance, and introduced the theme of the meeting 'Efficiency of Anaesthetic Services in the National Health Service'. Although there appeared to be a serious deficiency in financial provision for the NHS, the President pointed out that a vast sum of money was allocated by the Government. It was clear that opportunities existed for change in the NHS. New ideas should be considered and new concepts put forward but anaesthetists must ensure that any proposed changes which might affect the specialty of anaesthesia were satisfactory.

The importance and strength of the Linkmen organisation was emphasised by the President. He did however point out that there were still some gaps in the organisation. Not all districts had nominated Linkmen and unfortunately not all Linkmen were active. Linkmen were requested to identify any such gaps and report them to the Honorary Secretary. Linkmen were also reminded of the extensive programme of seminars being held at 9 Bedford Square. These were proving to be an excellent forum for the exchange of ideas. Linkmen were urged to attend and to encourage their colleagues to do likewise.

Supervision of patients in the operating theatre

The President compared the practice of anaesthesia in the UK with that practised in the USA and some European countries. The main differences in the UK were the presence of anaesthetic rooms, in assistance for the anaesthetist and the shorter duration of surgery. He strongly emphasised that, in the UK, the doctor is legally responsible for the continuous care of the anaesthetised patient in the operating theatre. This responsibility could not be delegated to a nurse or operating department assistant (ODA). The President stressed that although it is often suggested that delegating the care of an anaesthetised patient in the operating theatre to a nurse is analogous to the situation in the intensive care unit (ICU) this argument cannot be sustained. Patients in an ICU are not at risk of being disturbed by surgery, there is all round easy access to the patient and, generally, intensive care nurses are trained to, and have acquired, a higher level of relevant skills than their theatre colleagues.

The President then addressed the reasons for delegating the care of the anaesthetised patient to others and leaving the operating theatre. Several of these, including physiological and urgent calls to patients in the recovery room, were considered valid, others were not. Anaesthetists should not be expected to perform duties in more than one area simultaneously. All difficulties could be overcome; consultants and trainees working single-handed should be encouraged to get support from other anaesthetists when the necessity arises for them to leave the anaesthetised patient. It was unreasonable to expect anaesthetists to maintain full concentration over many hours. Departments should arrange for sufficient members of anaesthetic staff to be available to enable their colleagues to have regular breaks for rest and refreshment during very long operative procedures. A proposal, by the President, that an anaesthetist should normally be able to have a 15–20 minute break at least every 3 hours during very long surgical operations was approved by Linkmen.

The President then made comments about reasonable, responsible, behaviour in the operating theatre. Reading or listening to tapes during the conduct of anaesthesia distracted the anaesthetist's attention and this practice received severe criticism. If an anaesthetist's regular attitude to work was that it was boring, then counselling was indicated. In conclusion, the President stressed the need to ensure patient safety and urged Linkmen to work towards elimination of the dilemma faced by anaesthetists who, for valid reasons, require to leave the operating theatre and delegate the care of their anaesthetised patient to others.

Discussion. There was general agreement with the views expressed by the President from Linkmen. Several Linkmen, including Dr K.K. Dutt (*West Birmingham*), Dr J.W. Martin (*Burton on Trent*), Dr R.M. Weller (*Bristol*) and Dr B. Foster (*Manchester*) participated in the discussion. The matters raised included the following: the training and role of anaesthetic nurses, ODAs and recovery room nurses with a request that these be more formally delineated; medicolegal consequences resulting from an untoward event occurring to an anaesthetised patient while care was delegated to others; the increase in paperwork associated with administration of anaesthesia as a source of distraction during an anaesthetic. The President informed Linkmen that the training and the role of all who assist the anaesthetist, in and out of theatre, was under active consideration by Council.

Dr M.D. Milne (*Wolverhampton*), requested clarification of the position of trained anaesthetic nurses. In reply, it was stressed that anaesthetic nurses were not nurse anaesthetists and that in this country only registered medical or dental practitioners could administer anaesthesia. Dr T.B. Boulton, Immediate Past President, agreed and added that, in the case of dental practitioners they must also have received appropriate training in anaesthesia.

Minimal monitoring

In introducing this subject Dr J.A. Mathias (*St. Thomas' Hospital*) drew the attention of Linkmen to the article 'Standards for Patient Monitoring during Anaesthesia at Harvard Medical School', *Journal of American Medical Associations*, August 1986, **256**: 1017–1022.

A series of seminars held at 9 Bedford Square had shown that there was agreement, in principle, to establish recommendations applicable to the UK, to improve uniformity of patient care and to counter critical assessment in litigious situations. There were, however, differences of opinion on the need for, and the performance of, monitoring devices and on what may be considered to be clinical directives and erosion of traditional clinical freedom. Dr Mathias strongly recommended that guidelines be drawn up on routine minimal monitoring for all anaesthetised patients undergoing all types of surgical procedures. He suggested that monitoring devices should be available to enable continuous display of ECG, inspired oxygen concentration and pulse amplitude. There should be available a means of measuring arterial pressure regularly and the use of a disconnexion alarm and pulse oximeter were strongly recommended. Dr Mathias informed Linkmen that guidelines will be produced and published as an Association document. This will be made available to Linkmen and members by the summer of 1988.

Health Authorities must be made aware of the need for monitoring equipment in the promotion of patient safety. The Association document will assist anaesthetists to prepare lists of basic monitoring equipment which should be available in all anaesthetising areas and to persuade Health Authorities to make sufficient funds available for its purchase. Health Authorities should appreciate that the cost of providing this equipment would be considerably less than the sum awarded for a single damaged patient. It was also anticipated that equipment manufacturers will be encouraged to provide monitoring devices on anaesthetic delivery systems as standard, rather than optional extras.

Discussion. Professor J.G. Whitwam (*Hammersmith*) in making a plea for routine use of pulse oximetry during anaesthesia and recovery, outlined its clinical significance and cost effectiveness. Dr P.V. Scott (*Bromsgrove*) considered the recommendations identified standards of practice. He wondered whether new monitoring technology was just a fashion and felt its provision would present difficulties to Health Authorities. Dr J.H. Breed (*South Manchester*) was of the opinion that the recommendations should be advisory and not mandatory. Dr A.J. Whitaker (*Mansfield*) regarded routine use of pulse oximetry a high standard to attain; to be an effective safety measure it must be used by all anaesthetists on all patients. Dr J. Hurdley (*Selly Oak*) considered that Association recommendations will become regarded as a standard of practice and made the comment that monitoring can distract the anaesthetist; furthermore, the application of monitors may introduce delays. Dr J.N. Lunn, Editor, urged Linkmen to accept the overseas experience on the value of routine monitoring. High standards of practice had been achieved. In the USA the rate of increase in medical malpractice insurance premiums had decreased when routine monitoring was practised. In this country the Medical Defence Associations would welcome the introduction of guidelines on monitoring standards. Dr Lunn also stressed the importance of performing a routine safety check on the anaesthetic machine prior to use. Linkmen approved the concept of routine minimal monitoring.

Intensive care and high dependency units

Dr J.F. Searle, Council member, introduced the subject and informed Linkmen of the increasing concern of Council about the care of seriously ill patients. Many of these patients, having undergone major surgery or being treated in the ICU, are the direct concern of anaesthetists. Anecdotal reports would seem to indicate that standards of intensive care may vary throughout the country. The main areas of concern are: a shortage of appropriately trained nursing staff, a lack of accurate information on the specialties involved in the delivery of intensive care; a lack of contractual allowance (NHDs) for intensive care duties; a paucity of data from which future manpower requirements may be calculated.

Council did not accept the information published in the report 'Medicine in the Eighties' *British Medical Journal* 1986, 293: 547–550, and were of the opinion that delivery of intensive therapy and high dependency care was, in the main, provided by anaesthetists. To identify the anaesthetists' unrecognised service commitment to these areas, and to obtain accurate information, Council has set up two Working Parties. The Working Party on High Dependence Units (HDUs) has been asked: to enquire into the number and nature of HDUs in the UK; to consider the clinical and economic value of such units; to make recommendations for future developments.

The Intensive Care Advisory Group has a different remit, namely: to advise Council on the role of anaesthetists in the ICU; to determine the extent to which this is being achieved; to advise what improvements are needed.

A survey has been carried out through the Linkmen Organisation in all 239 Districts, Health Boards and Management Units in England, Wales, Scotland and Northern Ireland. This has identified 290 ICUs. Consultants in charge of these units have been requested to complete a detailed questionnaire on the ICU service in their District. A preliminary analysis of the data obtained has revealed that consultant anaesthetists were in administrative charge of 264 ICUs, 23 were administered by consultants in other specialties and in three units there was no consultant in charge. The full results of the survey, together with recommendations for provision of intensive care services, contractual allowance, manpower and training implications, will be published as an Association Document in 1988 and will be made available to Linkmen and members. Dr Searle concluded by thanking Linkmen for their invaluable assistance with the survey.

Discussion. Dr A.E.L. Nichol (*Barnet*) stressed the value of HDUs and predicted an increase in the number of these units due to shortage of nurses to staff general wards. Dr K.K. Dutt (*West Birmingham*) strongly supported the role of the English National Board (ENB) courses on critical care nursing in maintaining the supply of trained nurses. Dr A.J. Whitaker (*Mansfield*) was of the same opinion and commented that it was almost impossible to persuade Management to release funds for secondment of nurses to these courses. Dr M. Marshall (*Newcastle upon Tyne*) observed that nurses often choose to work in these units because of their previous experience as trainees within such areas. This would be prevented by implementation of Project 2000. Dr Searle, in his summing up, commented that the precise number of HDUs in the UK was not known.

Anaesthetic services for smaller obstetric units

Dr Rosemary Macdonald (*Leeds*) made reference to the considerable improvements achieved in recent years in levels of anaesthetic care available in obstetric units. However, there was continuing concern over the limited anaesthetic service available in many of the smaller units, some of which may be geographically isolated and, therefore, difficult to staff.

Limited financial and manpower resources place practical constraints on anaesthetic staffing levels and facilities. These anxieties have led the Association of Anaesthetists and the Obstetric Anaesthetists' Association to set up a joint Working Party to make recommendations and to draw up a plan for the future. Anaesthetic care available in all obstetric units must be to the same high standard irrespective of their size and geographical situation. A report has been produced by the Working Party and publication was at an advanced stage. This report will be sent to all Linkmen and will also be made available to members. The main recommendations contained therein are:

Immediate action. A named consultant anaesthetist should be responsible for the obstetric anaesthetic services in each Unit or District. This responsibility should be recognised by the allocation of NHDs; in small units with infrequent requests for anaesthesia, immediate consideration should be given to the withdrawal of anaesthetic cover. Selection of mothers to be delivered in smaller units should be improved and more emphasis placed on maternal risk factors; mothers should be given information if the range of anaesthetic services available in a unit is restricted. Admission to a unit with a comprehensive service should be offered as an alternative; courses to train midwives in assistance for the anaesthetist and in adult resuscitation procedures should be introduced.

Long-term action. Small obstetric units which offer a substandard level of anaesthetic service should be closed, amalgamated or relocated to within a District General Hospital or unit where full services are available. A single unit in each District is strongly recommended; exceptionally, if it is essential on geographical grounds to maintain an isolated unit, this should be recognised and recommended levels of anaesthetic staffing allocated to provide the necessary standard of care; substandard levels of service should be identified, documented and brought to the attention of Health Authorites and the public. The possible consequences of a substandard level of service should be emphasised.

Discussion. Dr M.R. Bryson (*Newcastle upon Tyne*) regarded obstetric units of medium size difficult to staff and considered that anaesthetists may also have to perform duties in the ICU or operating theatre while on-call for obstetrics. Dr Macdonald replied that anaesthetists should not be expected to perform two duties simultaneously. A designated consultant anaesthetist in all units was the first objective. Consideration may have to be given to one obstetric unit per two Districts to solve the anaesthetic staffing dilemma.

Assistance for anaesthetists

Dr M.M. Burrows, Honorary Treasurer, introduced the subject and outlined two main areas of controversy and dissatisfaction. These were the number and level of training of assistants; the poor status, conditions of service and salary scales of one group, the ODAs.

Council had set up a Working Party which, through the Linkman organisation, had conducted an enquiry into present provision of assistance for anaesthetists. This enquiry had clearly demonstrated the wide disparity between hospitals in the standard and availability of assistance. Seven hospitals, both teaching and district general, where levels of assistance were reported as being adequate had been visited by members of the Working Party. Dr Burrows expressed his gratitude to Linkmen for their assistance with the enquiry and also for hosting visitors. He then reported the findings as follows: a mix of assistants, namely registered nurses, enrolled nurses, and ODAs could be successful; all emergency admissions should be concentrated on one site within an individual District; continual 'in-service' training was essential. The number of ENB courses for training anaesthetic nurses was insufficient; a consultant anaesthetist should be designated in each District to be responsible for anaesthetic assistants and their training; divisions of anaesthesia should instigate and adhere to a policy of no assistant, no anaesthetic.

Dr Burrows hoped that this evidence, when published, will be helpful to anaesthetists in their efforts to achieve satisfactory levels of assistance. He concluded by referring to the grossly inadequate pay scales for ODAs which continue to be a source of serious concern. Consideration was being given to ways of improving this disgraceful situation.

Discussion. Dr D.J. Wilkinson (*St. Bartholomew's Hospital*) said that the basic NHS ODA salary was considerably less than that paid by the agencies. A manoeuvre to enhance remuneration was to promote ODAs to SODAs and SODAs to the medical physiological technician grade. Dr I. McLellan (*Leicester*) did not regard this as a long-term solution. Dr Srivastava (*South Tyneside*) was concerned that ODAs did not receive on-call payments. Dr M.R. Bryson (*Newcastle upon Tyne*) requested clarification of the roles of the different groups who act as assistants. Dr P.V. Scott (*Bromsgrove*) had found a nurses-only system to be satisfactory. Dr D.C. Hughes (*Surrey*) considered trained assistance essential and urged Linkmen to encourage ODAs to join the British Association of ODAs, thereby making this body more influential.

Dr M.M. Burrows replied that there were still a few anaesthetists who did not value assistance. He explained ODAs' access to the negotiating forum and concluded by informing Linkmen that the specific roles of assistants will be defined during the coming year.

Stress amongst trainees in anaesthesia

Dr P.J. Helliwell, Past President, introduced this topic and said that the incidence of suicide was not a good index of stress. There was evidence of stress in trainees in all specialties but this seemed to be more apparent in anaesthesia because of times on duty and the high degree of responsibility imposed on young and inexperienced doctors. Over the past few years, members of the Junior Anaesthetists' Group have become increasingly concerned that the stress to which trainees were being subjected was rising to an unacceptable level. A survey had been carried out among Junior Linkmen in 1986 and had brought to light some disturbing features. The survey clearly demonstrated that the life of a trainee anaesthetist was lonely and somewhat undervalued; trainees were often exposed to a lack of caring attitudes by staff around them; anaesthesia was the 'sharp end' of medicine and demanded a high degree of technical skill. A substantial proportion of trainees (30%) surveyed did not feel competent to manage their first unsupervised emergency case. Being a member of the resuscitation team and being responsible for tracheal intubation at an early stage of training was stressful. Most trainees, however, considered off-duty time adequate but consecutive hours of work excessive and fatiguing; consultant advice on clinical and career matters was not readily available. There was little social contact with seniors and, in general, a sense of being unsupported. Comment was also made that to complain could jeopardise references and ruin career prospects.

Council has decided to set up a Working Party in which the Faculty of Anaesthetists has agreed to participate, to examine the problem. The first task is to decide whether or not such fears are justified. If the answer is yes, then we require to seek a remedy.

Discussion. Dr S.A.I. Helwa (*Enfield*) and Dr K.K. Dutt (*West Birmingham*) participated in the discussion. There was agreement that social contact with consultants was important and may be deficient. A mentor system for trainees, comprising younger consultants, was suggested. Dr Helliwell commented that social deprivation was not universal, reflected consultants' personalities and did not relate to type or size of hospital. Dr Helliwell concluded by requesting Linkmen to write to him submitting views which they considered would be helpful to the Working Party.

Registrar 'bulge' and some solutions

The President reviewed the current situation and said that in anaesthetics there appeared to be too many registrars in training to allow reasonable career progression. A large number of bodies, including the Faculty of Anaesthetists' Manpower Advisory Panel, were looking into the problem. Plans to reduce the number of UK graduates were circulating but are not likely to be implemented for some years. Clearly, it was time to make plans for the future and it was the duty of consultants to ensure a realistic career ladder in the interests of trainees. Optimal flexibility can be achieved if anaesthetists in each Health District prepare plans for managing the service with various reductions in registrar establishment, rather than have national schemes imposed upon them. Practical solutions will be more likely to be adopted by Health Authorities, especially if phased over a reasonable period. It must be clearly understood that consultant anaesthetists on call are not required to be resident in the hospital.

A problem area was obstetric anaesthesia. Although this service is mainly provided by registrars, other grades of staff, appropriately skilled and experienced with more than one year's training, could perform this duty. When judged to be proficient in maternal resuscitation SHOs could administer epidural analgesia under consultant supervision. Nonconsultant grades of staff could do night duty; this should be agreed on appointment. Undoubtedly, concentration of resources was one of the key factors in providing efficient emergency services. Obstetrics, accident and emergency and ICU services should be grouped together for better efficiency. The only alternatives are to do nothing or to prepare for the eventuality of reduced numbers of trainees. Linkmen were advised most strongly to work for plurality of solutions.

Discussion. Dr J. Hurdley (*Selly Oak*), Dr D.G. Tweedie (*Warwick*), Dr J.F. Searle (*Exeter*), Dr J.W. Martin (*Burton-on-Trent*), Dr J.S. Sprigge (*Wirral*) and several other Linkmen took part in the debate. The following main points were raised. Clear definition of the responsibilities, duties and supervision of the subconsultant grades was considered necessary. Concern was expressed about the fact that the Clinical Assistant's contract does not make provision for continuing training. Trainees were considered to act as a stimulus to consultants and there was anxiety that these may be withdrawn from District General Hospitals. There was a general opinion that consultant numbers must be increased to prevent a fall in the standard of patient care.

The President, in reply, agreed with this opinion and said that the profession must work towards making further consultant expansion acceptable to government. In his concluding remarks the President assured Linkmen that the situation would be kept under review and the matter would be discussed again at the 1988 Linkman Conference.

Confidential enquiry into perioperative deaths

Dr J.N. Lunn, Editor, reported the imminent publication of the report of this unique joint enquiry of the Association of Anaesthetists and the Association of Surgeons. Three regions, Northern, South Western and North East Thames had participated. The report was based on half a million operations and there had been a participation rate of 96% from individuals and 100% from institutions. Dr Lunn intimated that the results of the enquiry would show considerable differences beween surgeons' and anaesthetists' perception of problems and also that previously reported figures for death directly attributable to anaesthesia had been overestimated. Death directly attributable to surgical intervention and management was a significantly more frequent event. Dr Lunn then stated that anaesthesia was leading the way ahead with this type of clinical audit. What was going to be done in the future was more important than what had already been accomplished. A national CEPOD was the next objective and it was hoped that funds would be forthcoming to finance this initiative. It was a question of when, not whether, to go ahead nationwide.

Survey of anaesthetic practice

Dr W.L.M. Baird, Assistant Honorary Secretary, described the survey the Association is initiating to extend its interest in quality control, the study of critical incidents in anaesthesia and in morbidity, as distinct from mortality, associated with anaesthesia. The aims of the survey are as follows: to obtain information on current anaesthetic practice throughout the UK by sampling a broad cross-section of both teaching and district general hospitals; to identify particular subjects for more detailed future study on a national basis.

The intention is to survey 10 000 anaesthetics by recruiting 400 anaesthetists including consultants, trainees and those in nonconsultant career grades. Each anaesthetist will be asked to complete a detailed questionnaire for each of 25 consecutive anaesthetics for which they have been responsible. Anonymity will be preserved by ensuring that the questionnaire bears no identification of the patient or anaesthetist. The anaesthetics may include both elective and emergency cases and may be from both NHS or independent practice. Day-stay patients should be excluded since follow-up at 24 hours is not feasible. The survey is entirely voluntary. Anaesthetists are being asked to do this purely for the advancement of the specialty and as part of the continuing process of professional audit. The information derived will provide a unique database and it is hoped that in due course the results will be published. Dr Baird concluded by requesting Linkmen to recruit colleagues in their districts to ensure wide geographical representation.

Discussion. Comment was made that the survey would be unrepresentative as only enthusiasts would volunteer. In reply to a question from Dr D.J. Wilkinson (*St. Bartholomew's Hospital*) Dr Baird said that initially completion of the questionnaire, which could be done retrospectively, might take up to 30 minutes but with practice this could be reduced to some 10 or 15 minutes.

Honorary Secretary's update

Dr P. Morris, Honorary Secretary, reported on the official opening of 9 Bedford Square on 9 July 1987 by Her Royal Highness, The Princess Margaret, Countess of Snowdon. The historic official ceremony and unveiling of the commemorative plaque took place in a marquee in Bedford Gardens, through the courtesy of the Marquess of Tavistock. There was a large audience of distinguished guests and members.

Servicing of BOC anaesthetic machines, series G,H,K, and L, which have been in service for over 20 years is being discontinued by BOC. The Safety Committee's recommendation is that these machines should be replaced.

The Association wished to commemorate the unequalled contribution of Sir Ivan Magill to world anaesthesia, in the form of a medal to be awarded for innovation in anaesthesia. An appeal fund has been opened to endow the medal. Donations are requested, to be sent to the Honorary Treasurer at 9 Bedford Square.

The Analocum System is still available for use by members. Funds raised through this system will be channelled into educational and academic activities.

The Association official travel agent for the World Congress of Anaesthesiologists, to be held in Washington, DC, 22–28 May, 1988 is Fishley Sebley. Linkmen who have not received information were advised to contact the firm.

The Honorary Secretary asked Linkmen to inform the Association when any change of Linkman took place in their district to enable the Linkman list to be kept up to date.

Open forum

Adverse drug reactions

Professor W.S. Nimmo, Council member, reported that yellow card reporting had revealed remarkably few problems associated with propofol. Following some 400 000 administrations, twitching had been reported on nine occasions. He reminded Linkmen that the data sheet information stated that the drug was suitable for induction of anaesthesia and maintenance for up to one hour duration. Currently, the drug is not licensed for longer periods. Dr J. Hurdley (*Selly Oak*) did not consider twitching to be a minor problem.

Reasons for bed closures and restriction of operations

Dr A.K. Adams, Dean, Faculty of Anaesthetists, reported a decrease in recruitment of SHO anaesthetists. She enquired of Linkmen as to what effect this was having on workload. About one third of Linkmen present considered anaesthetic and surgical workload had been adversely affected by failure to recruit. Dr J. Ormrod (*University College Hospital*) said that one in five operating theatres were closed in her hospital from lack of nurses. She attributed this to better conditions of service in the private sector and asked if the Association could exert its influence to reverse the trend. Dr R. Bose (*Swansea*), Dr P. Cartwright (*Derby*), Dr A.S. Laurence (*Preston*), and several other Linkmen also presented their views on the reasons for shortage of theatre nurses.

Extended role for ODAs

Dr G.P.M. Clark (*North Sheffield*) reported that his Health Authority was considering an extended ODA role to include tracheal intubation and intravenous cannulation in cardiac arrest and emergency situations. A discussion document had been drawn up by the Health Authority on this matter. Nurses were, however, not in agreement and there may be legal implications. Dr I. McLellan (*Leicester*) confirmed that his regional solicitor saw no legal objections to this extended role. Dr J.F. Lees (*Carshalton*), Dr G.T. Whitfield (*Scarborough*), and Dr A.S. Laurence (*Preston*), also expressed views.

Overseas training scheme, shortage of trainees and recruitment difficulties

Dr A. Leslie (*Walsall*) asked what had happened to the scheme. She was experiencing severe difficulties in recruiting trainee staff and was having to use agency locums. In reply, Dr A.K. Adams, Dean, said that the Bernard Johnson Postgraduate Advisor at the Faculty was interested to hear of suitable training posts. Difficulties have been experienced with GMC registration; there was no statutory requirement to advertise training posts and an attempt was being made to streamline PLAB. Dr C. Maile (*Worcester*), Dr J.R. Jenkins (*Great Yarmouth*), Dr S. Srivastava (*South Tynside*) and several other Linkmen contributed to the discussion. Dr M.M. Burrows, Honorary Treasurer, made the point that a career in general practice was now more attractive but he predicted that in about 3 years this trend will be reversed.

Anaesthetic textbooks in medical libraries

Dr K.W.Martin (*Burton-on-Trent*) made a plea for all anaesthetic text books to be catalogued and filed under one vacant code, 'anaesthesia', rather than being dispersed within the surgical specialties.

Rationalisation of pre-operative guidelines

Dr P.A. Wilson (*Ayreshire and Arran*) asked if Association guidelines should be drawn up to permit rationalisation of pre-operative investigations. Linkmen were requested to inform the Association of their views and recommendations.

Monitoring of patients receiving epidural opioids postoperatively

Dr J.R. Fozard (*Guildford*) asked for advice on this problem. Linkmen agreed that, generally, these patients should be initially admitted to a high-dependency area or ICU.

Other subjects raised in the open forum were: study leave expenses, visiting of departments by trainees prior to short-listing for an appointment, the Association document giving advice on smoking and the NAWCH charter for children in hospital; Dr A.C. Thurlow (*St. George's Hospital*) commented that threats of legal action had secured payment of study leave expenses; Dr M. Marshall (*Newcastle-upon-Tyne*) regarded visits prior to short-listing as canvassing and considered that this practice should be discouraged; Dr W.M. Ramsden (*Stoke*) was informed that the antismoking document would be available in the near future and will be tested in a pilot study; Dr P. Morris, Honorary Secretary, informed Linkmen that following receipt of full information Council had endorsed the NAWCH document; The President, Professor Rosen, then thanked Linkmen for their valuable and informed contributions and declared the Meeting closed.

THIS PAGE CONCERNS YOU IF YOU ARE A MEDICALLY QUALIFIED ANAESTHETIST IN GREAT BRITAIN AND IRELAND, OVERSEAS OR IN TRAINING AND ARE NOT YET A MEMBER OF THE ASSOCIATION OF ANAESTHETISTS OF GREAT BRITAIN AND IRELAND OR IF YOU ARE A MEMBER OF ANOTHER PROFESSION WHO PRACTISES IN ANAESTHESIA AND YOU WISH TO APPLY FOR ASSOCIATE MEMBERSHIP

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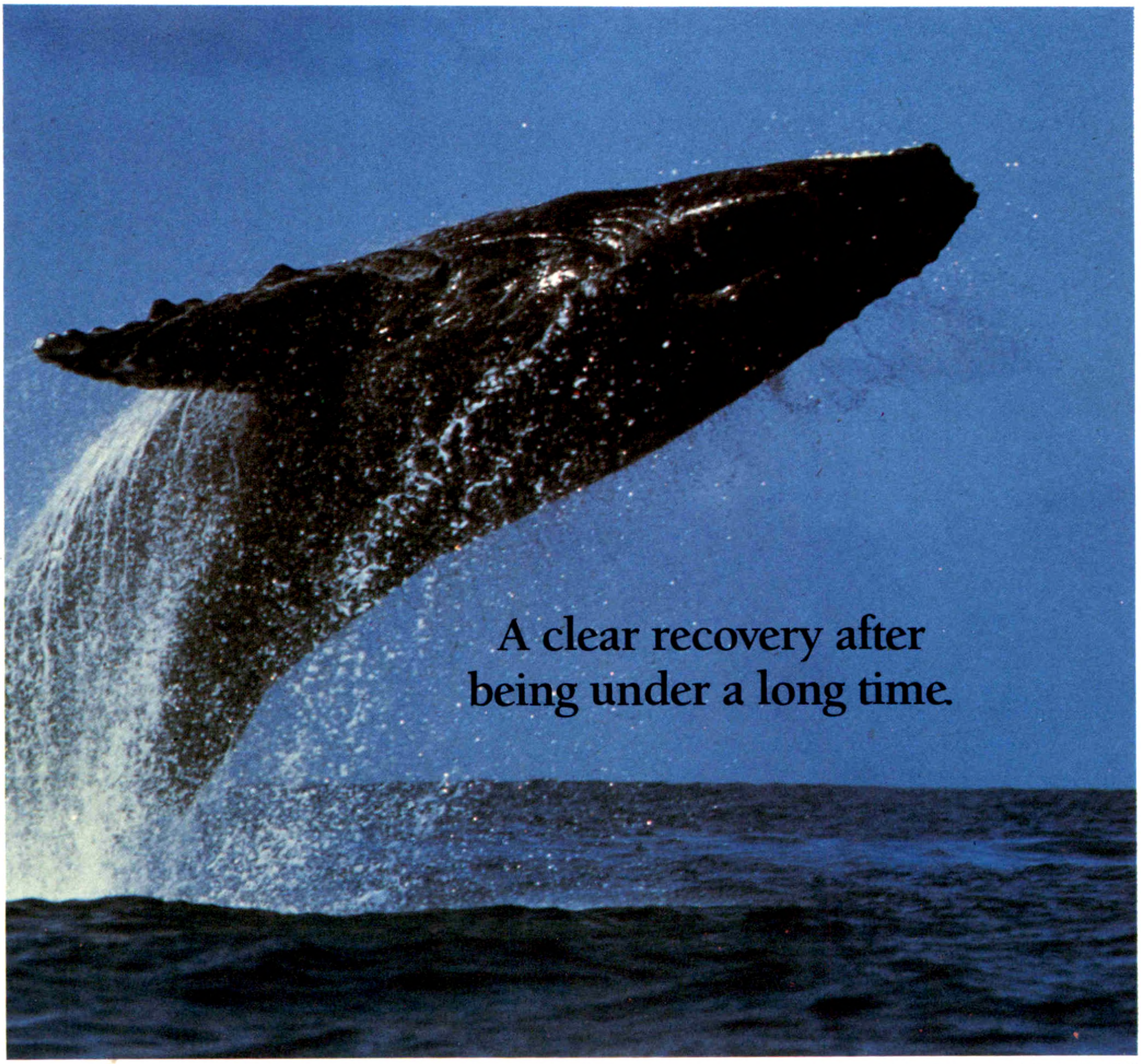

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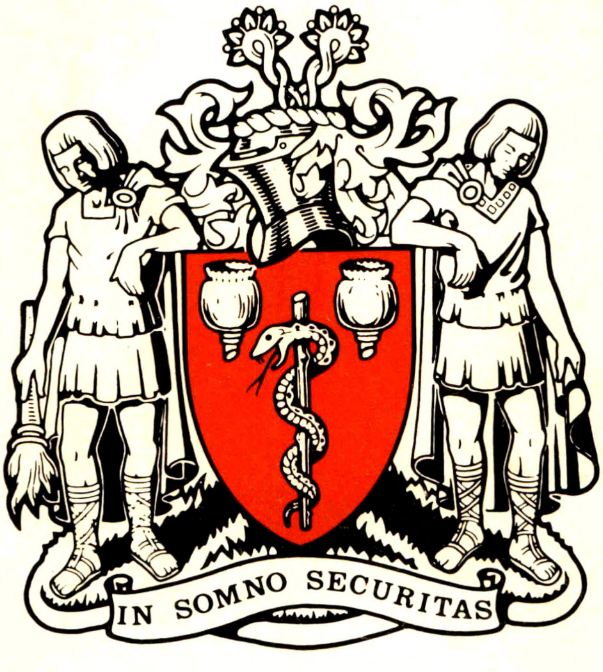

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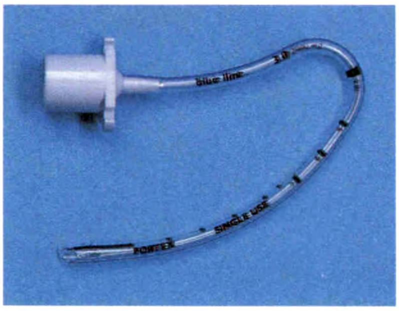

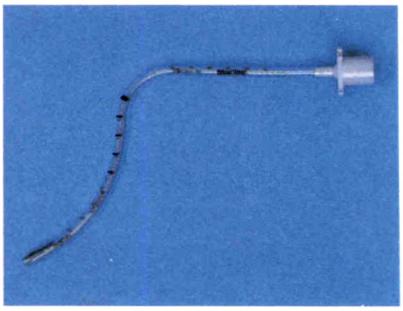

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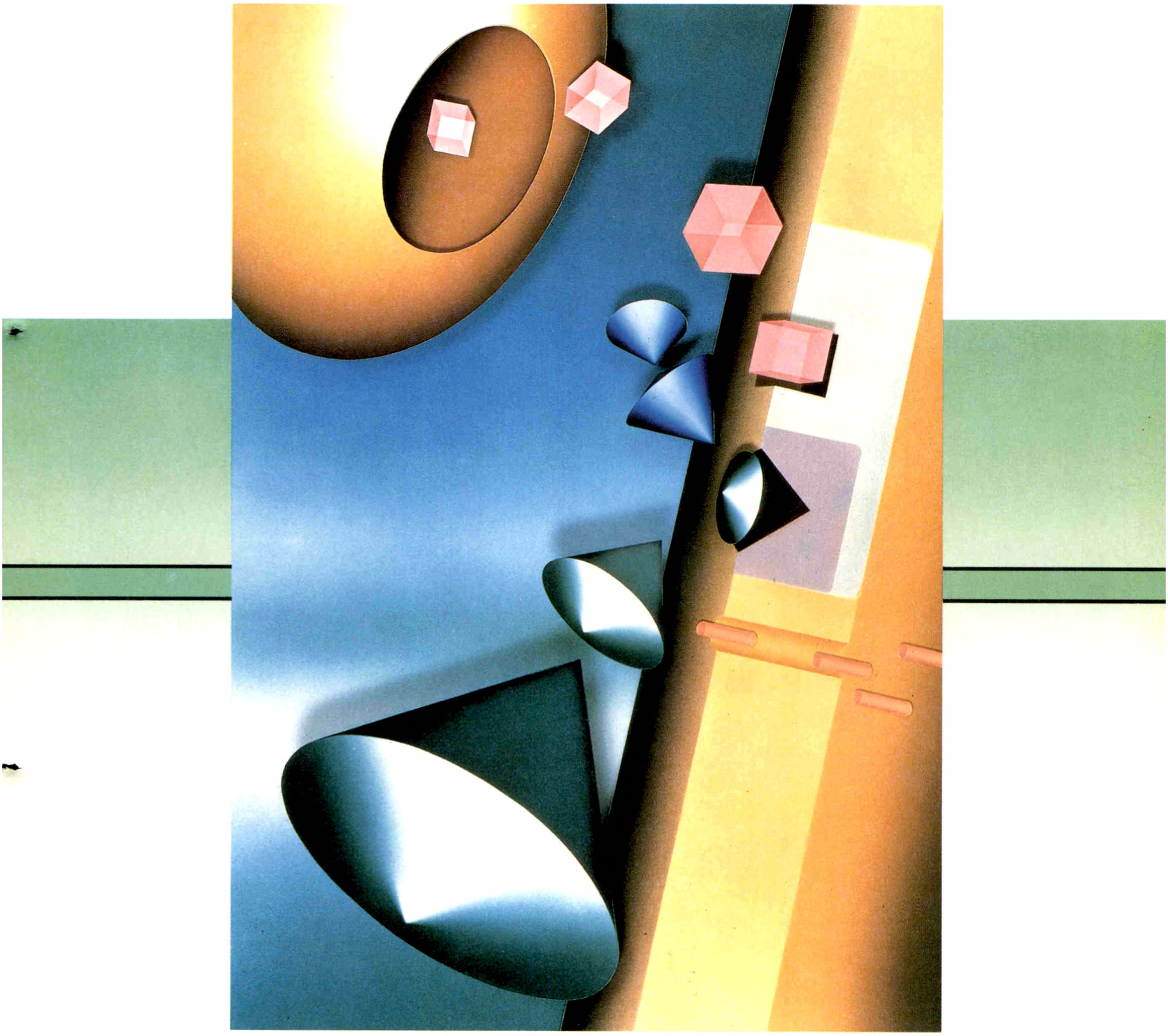

Artist's impression of how Anexate (green) competitively displaces the benzodizepine agonist (blue) from the receptor and neutralises its effects.

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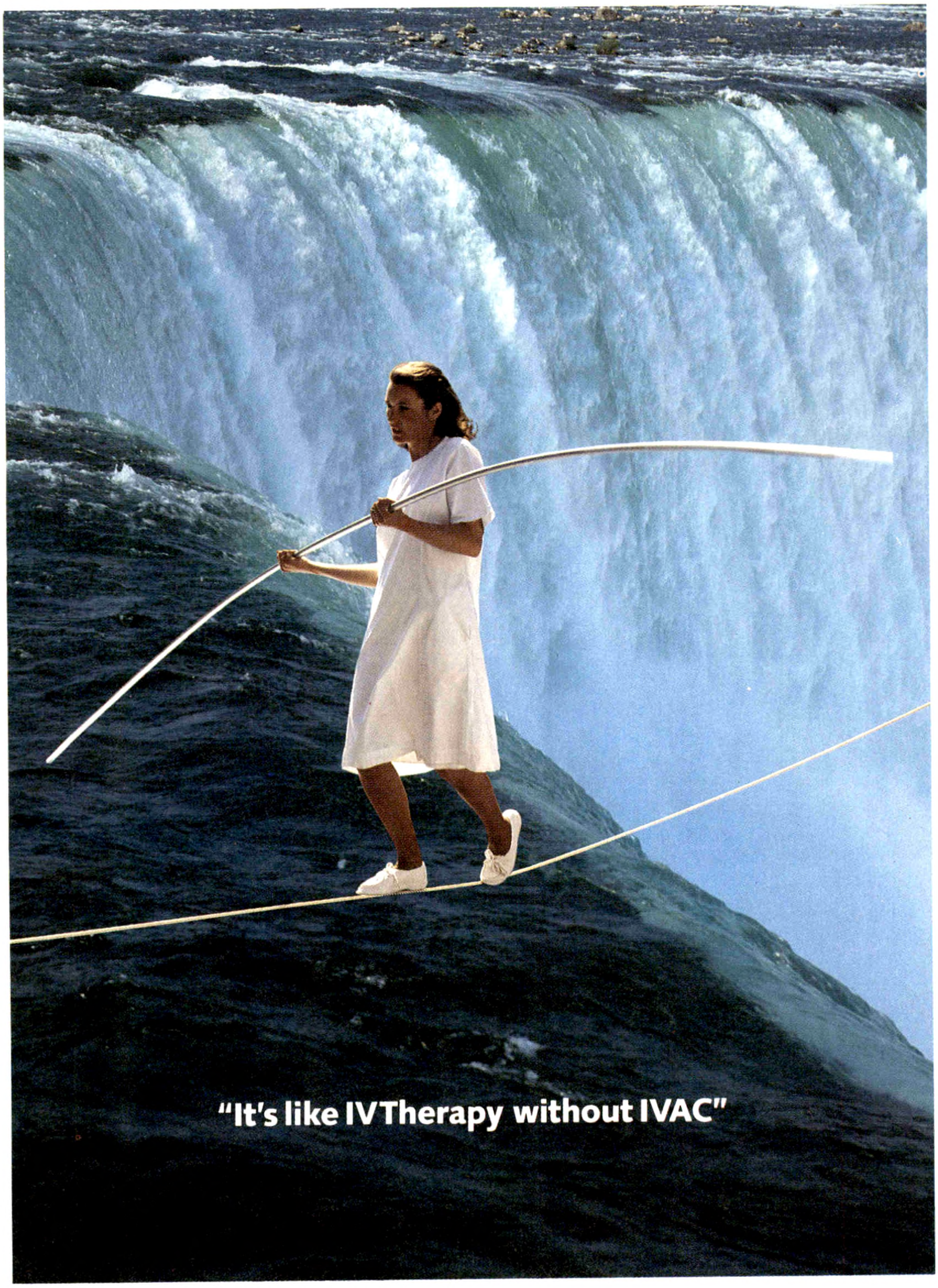
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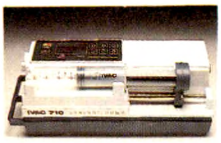

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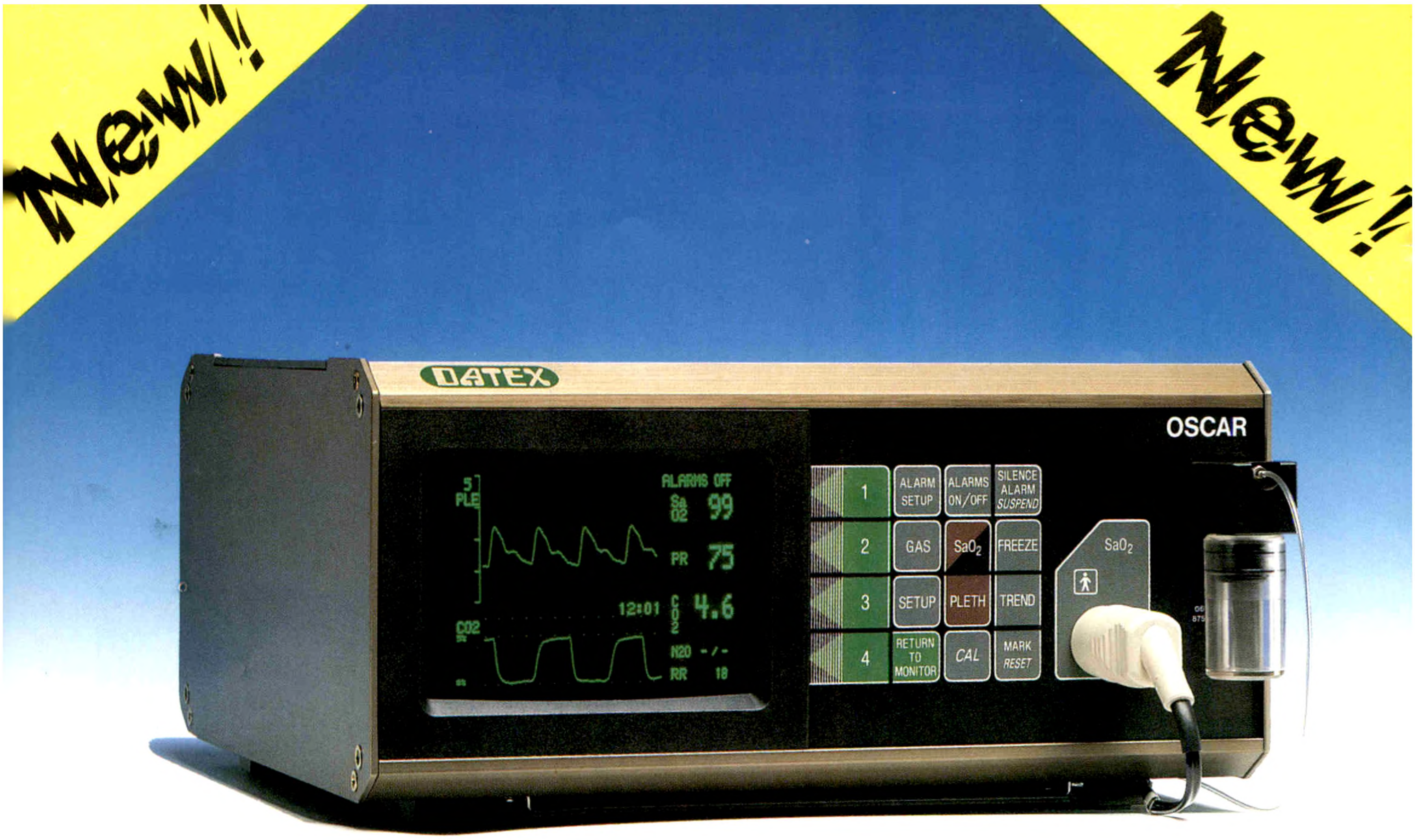

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CONTRA-INDICATIONS, WARNINGS, ETC. Concomitant use of central nervous system depressants, e.g. alcohol, general anaesthetics, narcotic analgesics or antidepressants, including MAOI's will result in accentuation of their effects. Treatment with diazepam may cause drowsiness and increase the patient's reaction time. This should be considered where alertness is required, e.g. driving a car. As with any benzodiazepine, excessive or prolonged use may result in the development of some psychological dependence with withdrawal symptoms on discontinuation. Use with caution in patients with impairment of renal or hepatic function.

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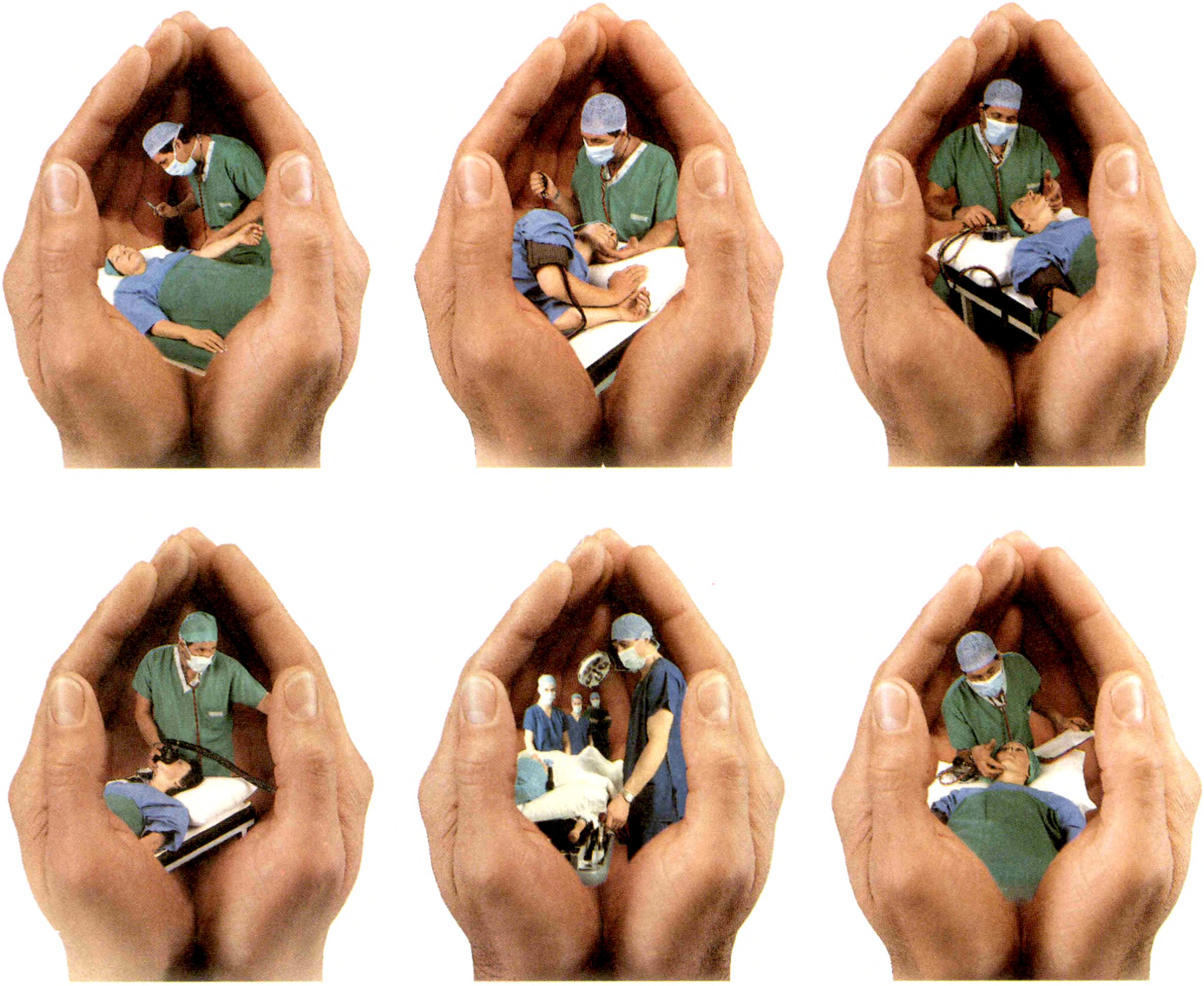

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Anaesthesia, 1988, Volume 43, pages 727–728

Editorial

Counselling on malignant hyperpyrexia

The occurrence of Malignant Hyperpyrexia (MH) during anaesthesia precipitates an acute crisis for patient and anaesthetist, and heralds a long-term crisis for relatives over, perhaps, several generations. This urges sympathetic and responsible counselling, and will make heavy demands on the anaesthetist who undertakes to respond.

The writer is involved in counselling three separate and unrelated family groups who live within the catchment area of his practice in the National Health Service; he has managed the occurrence of proven MH in a member of each family between 1971 and 1976. The 1971 patient survived a severe manifestation of the syndrome, which included cardiac arrest and postoperative renal failure, remains well and is now a mother of two. The second patient had fulminant MH and did not survive a second cardiac arrest. The third patient (1976) in whom the syndrome subsided, after immediate abandonment of the procedure when extreme tachycardia attended suxamethonium-facilitated tracheal intubation, survived unscathed and is now also a mother. The diagnosis of MH was confirmed in the probands who survived, in certain of their relatives and in relatives of the one who did not survive, through muscle biopsy studies. These will be referred to later.

Counselling of those families has now continued for almost 17 years and has been called on regularly over that period, and in recent months. The suggestions which follow are inevitably based on experience which has demonstrated the strengths and weaknesses of a counselling, cautionary, service.

The occurrence of MH within a family, fatal or not, engenders acute anxiety and a sense of crisis. It is essential that the family group should encounter early a counsellor who can reliably interpret the MH scene for them. It has been discomfiting to note how readily unreliable advice can be offered and accepted. The international literature on the subject, now voluminous, is not consistently illuminating. Informed anaesthetists can distinguish between the speculative and the substantiated, but casual interpretation of published material may be misleading. Anecdotal accounts of unproven, even unlikely, 'cases' of MH are given disproportionate weight. Triggering of the syndrome may be ascribed to innocent drugs and 'protection' or benefit wrongly attributed to others. A prime role of a counsellor, who has personal knowledge but does not claim to be an expert, is to evaluate published material critically on behalf of those counselled.

It is valuable to invite all adult and adolescent members of the family group to an informal meeting in the friendly but professional environment of a local Postgraduate Centre. The purpose is to encourage open discussion within which answers to questions will be factual and honest, and uncertainty will not be disguised. Misconceptions, sometimes the consequence of uninformed advice, must be patiently tolerated but firmly corrected. Two useful developments can ensue, and should be cultivated. The first is the supportive realisation, within the family group, that they can contribute to their personal safety rather than be passively anxious. The second is the emergence of one or more family group members who promise, and can be encouraged to assume, a leading role on behalf of the group. It has been disturbing to note that as months and years go by without further mishap the alertness of the family group diminishes. The intervention of a responsible relative, in warning the writer of an impending operation or obstetric delivery, has averted a possible disaster on eight occasions over the years.

The scene is set at the initial group meeting about the nature of MH, inherited susceptibility, triggering agents, the clinical features of the developed syndrome, and current understanding of prophylaxis and treatment. Collective memory is searched for any history of unexplained deaths under anaesthesia, or evidence of undiagnosed myopathies. These can be pursued in individual interviews later. A discussion on screening naturally follows. It is not difficult to persuade a family group of the importance of establishing a pathway of dominant inheritance when there is the promise that this can free one half of the family tree, over several generations, from anxiety. It is not necessary, at this early stage, to introduce the concept of 'autosomal dominant inheritance with reduced penetrance and varying expressivity' as described by Britt and colleagues[1] in 1969, or the suggestion by Gronert,[2] in his comprehensive review of the subject in 1980, that 'it seems likely that there is a multifactorial inheritance with a range of sensibilities'. Such complexities need not be introduced until the family group is comfortable in accommodating an outline of the overall scene.

Preliminary screening can be undertaken locally through family history as suggested above, and also through the measurement of resting muscle enzymes, and in particular creatine kinase (CK). The value of raised CK levels, in the prediction of MH susceptibility, was advocated as early as 1970[3] and was accepted by Ellis and colleagues[4] that this might be useful in a family in whom raised CK levels had already been shown to correlate with MH susceptibility. Correlation between raised CK and the halothane contracture test was reported later.[5] The writer's experience supports the correlation between raised CK levels and muscle biopsy conclusions. Local CK estimations not only suggested the pathway of dominant inheritance in the three family groups, but the estimations were also in accord with the conclusions derived from each one of the 10 subjects from the family groups who submitted to muscle biopsy studies. It is possible, in the writer's experience, to extend family screening to relatives living abroad. This was effected for a family of four who live in New Zealand, and was advised to relatives of another family who live in the North American Continent. It is proper to acknowledge that the value of preliminary CK screening is disputed.

There must be wide support for the advice that any putative diagnosis of MH, whether tentatively or confidently offered on clinical evidence, should require confirmation through muscle biopsy studies. We are condemned otherwise to a confusing

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situation in which the inferential, unsubstantiated, diagnosis of MH is proffered. Such studies were originally described[6] in 1973, and revised more recently within a protocol established by the European Hyperpyrexia Group.[7] It is difficult to envisage how to undertake responsible counselling and advice in the absence of such corroboration of an inheritance pathway and this becomes critical, as in the writer's experience, when a new generation emerges whose inherited MH susceptibility remains to be determined.

It is advisable to send a detailed letter to every member of the group after the initial counselling, with a copy to their general practitioners, which outlines the features of MH, warns of possible susceptibility, and advises about potential triggering agents if general anaesthesia is unavoidable. Where there is doubt concerning the triggering potential of a particular drug a 'worst case' approach should be taken. It should be emphasised strongly that this information must accompany any referral to hospital, and be presented at any attendance, and imperatively on admission for any form of treatment. This is the lynch-pin of the warning system. Each member of the family should be advised to register with MEDIC ALERT and to forward a copy of the counsellor's advice to that organisation. They should be exhorted to wear the warning disk at all times, especially on holiday, and particularly if abroad.

The pattern of inheritance will become clear as the screening process, including muscle biopsy studies, proceeds. It will then be necessary to convey updated information about MH susceptibility to each relative, each general practitioner, and MEDIC ALERT. The opportunity should be taken to advise also on any development in the MH scene. It is valuable and encouraging to reinforce the advice through another meeting with the family group. This meeting would include, for example, communication about the introduction of an agent such as dantrolene which is undoubtedly effective in porcine MH, and may yet earn the same unqualified reputation when the presumptive diagnosis of MH is confirmed, through muscle biopsy studies, in a number of survivors. It would also include the removal from suspicion of agents which have been unjustifiably named as possible triggering agents. This was the case with lignocaine and, by inference, the other amide-linked local anaesthetics mepivacaine and bupivacaine. Harrison and Morrell[8] critically analysed the basis for this speculation and, further, reported the negative response in MH-susceptible swine to intravenous infusions of lignocaine and bupivacaine.

No warning system is immune from carelessness. Families do grow inattentive as time passes when no danger is encountered. The writer has observed failures in the system over the years; he has shared the indignation of family members at the failure of their doctors to include vital information in hospital referrals, and at the failure of hospital doctors to appreciate its significance, or, worse still, to dismiss it as irrelevant. He has failed to persuade one relative, now a mother, to have her probable MH susceptibility confirmed or eliminated from consideration. He is aware that some subjects at confirmed risk do not always wear their MEDIC ALERT disks, or ensure that they always have their written counselling available for presentation. However, he is encouraged by the overall awareness and insight within the three family groups. This is undoubtedly fostered by the British Malignant Hyperpyrexia Newsletter which is extremely valuable in the promotion of knowledge, and mutual support, to concerned relatives in MH-afflicted families.

The vulnerability of anaesthetists in an increasingly litigious society is obvious, because the public presumes adequate knowledge and expects responsible counselling. It is entirely reasonable that some discharge of this responsibility be recognised, and the overall responsibility shared, if care is taken to institute a system of counselling which reliably informs patients at risk and equips them for self-protection, and enlightens other doctors about these risks. It is prudent to keep a permanent record of all advice offered.

Counselling in MH is demanding. The reward can be that disaster is prevented.

Mansfield and District General Hospital
Mansfield NG18 1PH

L. MULROONEY

References

1. BRIT BA, LOCHER WG, KALOW W. Hereditary aspects of malignant hyperthermia. *Canadian Anaesthetists' Society Journal* 1969; **16:** 89.
2. GRONERT GA. Malignant hyperthermia. *Anaesthesiology* 1980; **53:** 395–423.
3. ISAACS H, BARLOW MB. The genetic background to malignant hyperpyrexia revealed by serum creatine phosphokinase estimations in asymptomatic relatives. *British Journal of Anaesthesia* 1970; **42:** 1077–84.
4. ELLIS FR, CLARKE IMC, MODGIL M, CURRIE S, HARRIMAN DFG. Evaluation of creatinine phosphokinase in screening patients for malignant hyperpyrexia. *British Medical Journal* 1975; **3:** 511–3.
5. ISAACS H, HEFFRON JJA, BADENHORST M. Predictive tests for malignant hyperpyrexia. *British Journal of Anaesthesia* 1975; **47:** 1075–80.
6. HARRIMAN DGF, SUMNER DW, ELLIS FR. Malignant hyperpyrexia myopathy. *Quarterly Journal of Medicine New Series* 1973; **168:** 639–58.
7. ELLIS FR. European Malignant Hyperpyrexia Group. Editorial. *British Journal of Anaesthesia* 1984; **56:** 1181–2.
8. HARRISON GG, MORRELL DF. Response of MHS swine to i.v. infusion of lignocaine and bupivacaine. *British Journal of Anaesthesia* 1980; **52:** 385–7.

Editorial notices

Anaesthesia News

Copy for *Anaesthesia News* should be sent to the Editor as and when it becomes available. It is hoped that publication will occur within 2 months of receipt.

Manuscripts must be submitted in accordance with the internationally recognised *Uniform requirements for manuscripts submitted to biochemical journals* (*British Medical Journal* 1979; **1:** 432 5). Detials will be found in the Notice to Contributors to *Anaesthesia* at the end of this issue.

Anaesthesia, 1988, Volume 43, pages 729–732

Hapten inhibition and dextran anaphylaxis

K.-G. LJUNGSTRÖM, H. RENCK, H. HEDIN, W. RICHTER AND B.-E. WIHOLM

Summary

Hapten inhibition with dextran 1 has been used in Sweden since 1982 to prevent severe anaphylactic reactions to dextran. This has led to a reduction in the reports of severe reactions to dextran from 22 per 100 000 units of dextran used between 1975 and 1979, to 1.2 per 100 000 units between 1983 and 1985. The number of fatal reactions decreased from 23 to one. More than 600 000 units of dextran were used during each period.

Key words

Allergy; anaphylaxis.
Blood; replacement.

A preliminary report on the prevention of severe adverse reactions to dextran was published in 1980.[1] Clinical trials of hapten inhibition with dextran 1 for the prevention of severe dextran-induced anaphylactic reactions (DIARs) were completed in 1983; these demonstrated the efficacy of this method in approximately 130 000 patients.[2–6] The incidence of severe DIARs in clinical practice may be estimated with considerable accuracy in Sweden because the reporting of severe adverse drug reactions has been mandatory since 1975. The incidence of DIARs during the period 1970–1979 (before the introduction of hapten inhibition) has already been studied in detail.[7] Dextran 1 became available for clinical use in 1982. A comparison between DIARs reported before and after the registration of dextran 1 has made it possible to evaluate the efficacy of this preventive measure on a nationwide basis.

Patients and methods

Hapten inhibition

The principles of hapten inhibition have been described in detail elsewhere.[1,2,8–9] In brief, very low molecular weight dextran (dextran 1, MW 1000 daltons) is injected intravenously before an infusion of clinical dextran (dextran 70 or 40) is started, in order to block the antigen combining sites of preformed circulating dextran reactive antibodies (DRA). The prerequisites for immune complex formation, the triggering mechanism of severe DIARs, are thereby eliminated. In practice, 3 g of dextran 1 (20 ml of a 15% solution of Promit, Pharmacia AB, Uppsala, Sweden) are given intravenously immediately before the first infusion of clinical dextran. If repeated infusions are necessary, a renewed injection of dextran 1 is made only if the interval between infusions exceeds 48 hours.[10]

Reports on adverse reactions

We studied spontaneous reports on adverse reactions to dextran (Macrodex/Rheomacrodex/Promit) submitted to the Section for Adverse Drug Reactions, National Board of Health and Welfare, or the manufacturer (Pharmacia AB). The reports were supplemented with copies of anaesthesia charts and other records needed for a complete evaluation; they were classified in respect of severity according to principles described previously[2,7] (Table 1). The nomenclature of the National Board of Health and Welfare was used for assessment of the causal relationship: 'P' = probable or possible; 'N' = remote or not assessable. Analyses of the titre of DRA were performed, when possible, on serum samples drawn before the reaction.[11–12]

Dextran use

The use of dextrans increased in Sweden during the 1980s. The sales of Macrodex (dextran 70) and Rheomacrodex (dextran 40) during the period studied totalled 672 154 units; those of Promit (dextran 1) were 326 601 units. Dextran has also been sold by another manufacturer since 1982; however, these sales amounted to only a few percent

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Accepted 8 January 1988.

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Table 1. Severity of dextran-induced anaphylactic/anaphylactoid reactions.[2,7]

Grade of severity	Characteristic symptoms
I	Skin manifestations (flush, erythema, urticaria) Lumbar pain
II	Mild to moderate hypotension (lowest recorded systolic arterial pressure (SAP) > 40–60 mmHg depending on duration) Gastrointestinal disturbances Respiratory distress
III	Severe hypotension, shock (SAP < 40–60 mmHg) Bronchospasm
IV	Cardiac and/or respiratory arrest
V	Fatal reaction

Table 2. Reports on dextran-induced adverse reactions, types of reaction and causal relationship during 1983–1985 in Sweden. The number of units of clinical dextran administered was 672 154.

Causal relationship	DIAR, grade of severity					Miscel-laneous*	Total
	I	II	III	IV	V		
P†	51	19	7	0	1	9	87
N††	3	1	3	1	0	7	15
Total	54	20	10	1	1	16	102

* Nausea, fever, shivering, headache.
† Probable or possible.
†† Remote or not assessable.

of the total number of dextran units used. Adverse reactions to these products were not studied since the extent to which hapten inhibition was used in connexion with them was unknown.

Results

Adverse reactions to clinical dextran

A total of 102 reports on adverse reactions to Macrodex/Rheomacrodex after dextran 1 injection were retrieved during the period 1983–1985. DRA titres in serum samples drawn before the reaction were available in 54 cases. The reports were classified according to grades of severity and causal relationship as shown in Table 2.

One fatal reaction was reported. A 67-year-old man with signs of peritonitis and staphylococcal septicaemia was scheduled for emergency laparotomy. He remained in a critical condition (systolic arterial pressure 80 mmHg; pulse rate 130 beats/minute) before induction of anaesthesia despite pre-operative treatment with crystalloid solutions, albumin and antibiotics. Twenty millilitres of dextran 1 were administered intravenously, an infusion of Macrodex was started and ketamine 100 mg was given intravenously. Five minutes later, when 50–100 ml of dextran had been infused, the patient developed erythema and rapidly became cyanotic despite the administration of oxygen. Circulatory arrest ensued quickly and could not be reversed. Analysis of DRA by passive haemagglutination showed a titre of 1:2 048 before and 1:512 after the reaction. Precipitating DRA could be demonstrated with a gel diffusion technique in a concentration of 2.4 mg/ml in the serum sample drawn before the reaction. Autopsy showed an intra-abdominal abscess caused by a perforated diverticulum of the ileum, recent myocardial infarction, and a fatty liver.

Table 3. Comparison of incidences of DIARs during 1975–1979[7] (before dextran 1 introduction) and 1983–1985 (with dextran 1 prophylaxis).

	Units of dextran	DIAR, grades of severity					Total
		I	II	III	IV	V	
1975–1979	647 756	61	94	78	44	23	300
					145 (0.022%)		
1983–1985	672 154	51	19	7	0	1	78
					8 (0.0012%)		

Table 3 shows a comparison of the incidences of DIARs of different grades of severity for the periods 1975–1979 and 1983–1985. The incidence of severe reactions (grades III–V) decreased by approximately 95% from 22 to 1.2 per 100 000 units of dextran after the introduction of dextran 1. Only one case which led to cardiac arrest (described above) was reported during 1983–1985, whereas 67 such cases were reported during the period 1975–1979 when an equivalent number of units of dextran was used. However, mild (grade I) reactions have not decreased significantly.

We found seven additional reports during 1983–1985 of DIARs in which dextran 1 had not been given before clinical dextran. Two were of grade I, four of grade II and one of grade III. Five of these reactions occurred early during the study period in hospitals that had not yet started to use dextran 1. The injection of dextran 1 had been forgotten in one grade I reaction. The only severe reaction was also caused by a human error, in that an infusion of dextran 70 instead of glucose 5% was started by mistake.

Adverse reactions to dextran 1

Adverse reactions to the injection of dextran 1 were reported in 20 cases. Nausea was reported in five patients, skin manifestations in seven, transient bradycardia alone or in combination with hypotension in four and transient hypotension in four. Most of these reactions were mild and required no specific therapy, but one case with a fatal outcome was reported.

A 67-year-old man scheduled for total hip replacement under spinal anaesthesia was on treatment with diuretics and nitroglycerin for heart disease. A pre-operative electrocardiogram (ECG) showed signs of myocardial ischaemia. The patient was turned into a lateral position after spinal anaesthesia had been established using amethocaine with noradrenaline, and dextran 1 was given slowly intravenously. The injection was interrupted after 10 ml for reasons unrelated to the injection itself. The patient started to convulse and gasp for breath about one minute later. ECG monitoring was started at this stage, and showed sinus rhythm at first but this changed later to ventricular fibrillation. The patient's lungs were difficult to ventilate but no distinct bronchospasm was observed. Skin manifestations were absent. Resuscitation was unsuccessful. Analysis of DRA with a passive haemagglutination technique showed a titre of 1:1 024 before and 1:512 after the reaction. No precipitating antibodies against dextrans could be demonstrated in the patient's serum. Several signs of advanced heart disease were found at autopsy: coronary artery occlusions and severe stenoses, myocardial fibrosis which suggested previous infarction, and patchy myocarditis. The causal relationship was assessed as 'P', mainly because of the positive time relationship.

Discussion

The use of dextran in Sweden has increased considerably during the 1980s from 130 000 units to 225 000 units per year. On average, 2.1 units of clinical dextran were used for every unit of dextran 1 during 1983–1985; this is in accordance with previous estimates of the total need for dextran 1.[7] This finding, in combination with the fact that few reactions were reported in which clinical dextran was *not* preceded by dextran 1, indicates that the hapten inhibition concept has been accepted and applied widely in our country. This had been accompanied by a dramatic reduction in the reported number of severe reactions to dextran. The incidence of reports of severe DIAR is now only one eighteenth of that reported in the historical control material.

Estimates of adverse drug reactions (ADRs) from spontaneous reporting systems can always be criticised because of underreporting, particularly if different time periods are compared. It is known that reporting is more frequent during the first few years after a drug has been marketed; this would not induce a bias in favour of dextran 1. The total number of ADR reports in Sweden increased from an average of 2070 per annum in 1975–1979 to 2730 in 1983–1985, while the number of fatal ADRs reported annually remained constant at about 40. The rate at which ADRs are actually reported in Sweden has been found to be variable (40% for agranulocytosis, 77% for osteitis after BCG vaccination in infants and 100% for fatal thromboembolic complications of oral contraceptives); this variability probably reflects both the severity and the ease with which the causal relationship is understood.[13–15] There is thus indirect evidence that underreporting is not a serious problem with DIAR. The incidence of severe DIARs in 1983–1985 is of the same magnitude as that found in the clinical trials.[2–4] Finally, the incidence of grade I reactions (which are not considered to be antibody-mediated[16]) has not changed, and this indicates that the decreased incidence of severe reactions after introduction of dextran 1 was not because of a general decrease in the reporting of DIARs.

However, it should be emphasised that pre-injection of dextran 1 does not eliminate completely the risk of a severe DIAR. Adequate facilities for immediate resuscitation are still required. The fatal reaction that occurred in spite of pre-injection with dextran 1 is the first to be described since 1978, during which time an estimated total of over two million patients have received dextran 1. The critical condition of the patient before the reaction as well as the high concentration of precipitating antibodies probably contributed to the fatal outcome. Precipitating DRAs have been demonstrated in only a few previous cases.[12] The patient's circulatory condition may have prevented dextran 1 from entering the poorly perfused tissues; thus the unblocked antibodies could later have entered the central circulation and formed immune complexes with the infused clinical dextran. This hypothesis is supported by two previous reports of severe DIARs which occurred despite the use of dextran 1; these were reported before the registration of Promit. Both patients had advanced peripheral arteriosclerosis with impaired perfusion of large areas of the body. We suggest that a longer interval than the usual 1–2 minutes after the hapten injection should be allowed before the dextran infusion is started in patients with impaired peripheral circulation.

Side effects of dextran 1 were rare and generally of little clinical importance. The reported reactions consisted mainly of skin manifestations, usually in allergic individuals, and transient circulatory disturbances. We are unable to interpret these reactions as being immunologically mediated. They are perhaps related to the bolus injection of the slightly hyperosmotic dextran 1 solution. The causal relationship was assessed as 'P' in the fatal case secondary to dextran 1 injection because of the short time interval. Unfortunately, additional clarification by immunological or other analyses is not possible. The observed reduction of the DRA titre is within the methodological error.

Thus, the reported incidence of severe DIARs in Sweden has decreased almost twentyfold in the three years since the introduction of dextran 1. This finding strongly supports a wide application of this method, even in countries where severe DIARs are reported only very rarely. Differences in the incidence of elevated DRA titres may exist in different countries.[17] However, the apparent absence or very low incidence of reactions in some countries may be because of less complete reporting. Dextrans have proved their value in medical practice for almost 40 years. Severe DIARs are infrequent, and by routine application of the hapten inhibition principle, dextrans can be used therapeutically with even greater safety for volume replacement, prophylaxis against thrombosis and improvement of the microcirculation. The incidence of severe reactions to dextran reported in this study is only approximately one third of that reported to be caused by human serum albumin in a large trial.[18]

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References

1. MESSMER K, LJUNGSTRÖM K-G, GRUBER U-F, RICHTER W, HEDIN H. Prevention of dextran-induced anaphylactoid reactions by hapten inhibition. *Lancet* 1980; **i:** 975.
2. LJUNGSTRÖM K-G, RENCK H, HEDIN H, RICHTER W, ROSBERG B. Prevention of dextran-induced anaphylactic reactions by hapten inhibition. I. A Scandinavian Multicenter Study on the effects of 10 ml dextran 1, 15%, administered before dextran 70 or dextran 40. *Acta Chirurgica Scandinavica* 1983; **149:** 341–8.
3. RENCK H, LJUNGSTRÖM K-G, ROSBERG B, DHUNÉR K-G, DAHL S. Prevention of dextran-induced anaphylactic reactions by hapten inhibition. II. A comparison of the effects of 20 ml dextran 1, 15%, administered either admixed to or before dextran 70 or dextran 40. *Acta Chirurgica Scandinavica* 1983; **149:** 349–53.
4. RENCK H, LJUNGSTRÖM K-G, HEDIN H, RICHTER W. Prevention of dextran-induced anaphylactic reactions by hapten inhibition. III. A Scandinavian Multicenter Study on the effects of 20 ml dextran 1, 15%, administered before dextran

70 or dextran 40. *Acta Chirurgica Scandinavica* 1983; **149:** 355–60.

5. Laubenthal H, Peter K, Messmer K. Prophylaxe der Dextran-Anaphylaxie. *Münchener Medizinische Wochenschrift* 1982; **124:** 951–3. English title: Prevention of dextran anaphylaxis.
6. Laubenthal H, Peter K, Gruber UF, Gerber H, Messmer K. Multicentrische klinische Studien mit monovalentem Haptendextran in der Bundesrepublik Deutschland und in der Schweiz. In: Fortschritte der Dextran-Therapie. *Beiträge zur Anaesthesiologie und Intensivmedizin 3.* Wien: Verlag W. Maudrich, 1983; **3:** 43–55.
7. Ljungström K-G, Renck H, Strandberg K, Hedin H, Richter W, Widerlöv E. Adverse reactions to dextran in Sweden 1970–1979. *Acta Chirurgica Scandinavica* 1983; **149:** 253–62.
8. Richter W. Hapten inhibition of passive antidextran dextran anaphylaxis in guinea pigs. Role of molecular size in anaphylactogenicity and precipitability of dextran fractions. *International Archives of Allergy and Applied Immunology* 1971; **41:** 826–44.
9. Richter AW. Immune complex anaphylaxis induced by dextran and its elimination by hapten inhibition. In: Ring J, Burg G, eds. New trends in allergy II. Heidelberg: Springer Verlag, 1986: 272–83.
10. Schwarz JA, Koch W, Bühler V, Kaumeier S. Pharmacokinetics of low molecular (monovalent) dextran 1 (Dx 1) in volunteers. *International Journal of Clinical Pharmacology, Therapy and Toxicology* 1981; **19:** 358–67.
11. Hedin H, Richter W. Pathomechanisms of dextran-induced anaphylactoid/anaphylactic reactions in man. *International Archives of Allergy and Applied Immunology* 1982; **62:** 122–6.
12. Kraft D, Hedin H, Richter W, Scheiner O, Rumpold H, Devey ME. Immunoglobulin class and subclass distribution of dextran-reactive antibodies in human reactors and non reactors to clinical dextran. *Allergy* 1982; **37:** 481–9.
13. Arneborn P, Palmblad J. Drug induced neutropenia—a survey for Stockholm 1973–78. *Acta Medica Scandinavica* 1982; **212:** 289–92.
14. Böttiger M, Romanus U, de Verdier C, Boman G. Osteitis and other complications caused by generalized BCG-itis. Experiences in Sweden. *Acta Paediatrica Scandinavica* 1982; **71:** 471–8.
15. Böttiger LE, Westerholm B. Oral contraceptives and thromboembolic disease. Swedish experience. *Acta Medica Scandinavica* 1971; **190:** 455–63.
16. Richter W, Hedin H. Dextran hypersensitivity. *Immunology Today* 1982; **3:** 132–8.
17. Messmer K, Richter W, Takaori M. Prinzip der Haptenhemmung zur Prophylaxe der Dextrananaphylaxie: Immunologische Aspekte. In: Fortschritte der Dextran-Therapie. *Beiträge zur Anaesthesiologie und Intensivmedizin 3.* Wien: Verlag W. Maudrich, 1984; **3:** 15–27.
18. Ring J, Messmer K. Incidence and severity of anaphylactoid reactions to colloid volume substitutes. *Lancet* 1977; **i:** 466–9.

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The influence of anaesthetic technique on metabolism of oral morphine

M. P. SHELLY, B. L. TAYLOR, K. G. QUINN AND G. R. PARK

Summary

The pharmacokinetics of oral controlled release morphine were studied in 10 patients to investigate the effect of two different anaesthetic techniques on its absorption and metabolism. Five patients received general anaesthesia with neuromuscular blockade; the remainder received lumbar epidural analgesia with general anaesthesia but without neuromuscular blocking agents. Blood samples were collected throughout the peri-operative period for estimation of plasma morphine concentration using two radio immunoassay techniques, one specific for morphine, the other less specific and crossreacting with morphine glucuronides. Plasma morphine concentrations with the specific method were similar for the two groups of patients but there was a statistically significant difference between the two groups with the less specific method at 30 and 45 minutes after induction of anaesthesia. This difference was because of the varying concentrations of morphine metabolites and may reflect the change in splanchnic blood flow produced by lumbar epidural analgesia.

Key words

Analgesics; morphine.
Anaesthetic techniques; general, regional.

Effective relief of chronic pain can be achieved with oral controlled release morphine sulphate (OCRM, MST Continus, Napp Laboratories, Cambridge) but its role in the management of acute pain is less well defined. OCRM differs from parenterally administered morphine in several ways. It has been shown to have a low bioavailability,[1,2] although this view has been contested by other workers[3] and may reflect the different analytical techniques used. OCRM provides effective analgesia[1] and profound sedation in spite of the low bioavailability.[1,2,4,5] In addition it has been shown in volunteers to delay gastric emptying less than equipotent doses of parenteral morphine,[6] although gastric emptying may be delayed by postoperative administration of OCRM (A. R. Aitkenhead, personal communication).

Investigations of OCRM as pre-operative medication have shown it to produce sedation as well as intra-operative and postoperative analgesia[2,4,5,7] without delayed gastric emptying.[6] The use of OCRM in this way is controversial and its appropriate use during the peri-operative period is not yet established. The absorption and metabolism of morphine after pre-operative oral administration may be influenced by anaesthesia and surgery and these effects may be complex. This study was performed to investigate the effects of two different anaesthetic techniques on the absorption and metabolism of morphine from OCRM.

Methods

Ten patients scheduled to undergo major gynaecological surgery of greater than 60 minutes duration were studied. All surgery was through a lower abdominal incision and for a nonmalignant condition. No patient was receiving concurrent medication pre-operatively and none had evidence of gastrointestinal disease. The patients were fasted for 4 hours before the study and allocated randomly to receive one of two anaesthetic techniques. Approval for the study was obtained from the District Ethics Committee and all patients gave informed written consent to take part in the investigation.

An indwelling cannula was inserted into an antecubital fossa vein 2 hours before induction of anaesthesia to facilitate blood sampling. Twenty milligrams of OCRM were administered after a baseline blood sample had been obtained. Blood samples were then withdrawn every 30 minutes for 2 hours, at 15-minute intervals during surgery

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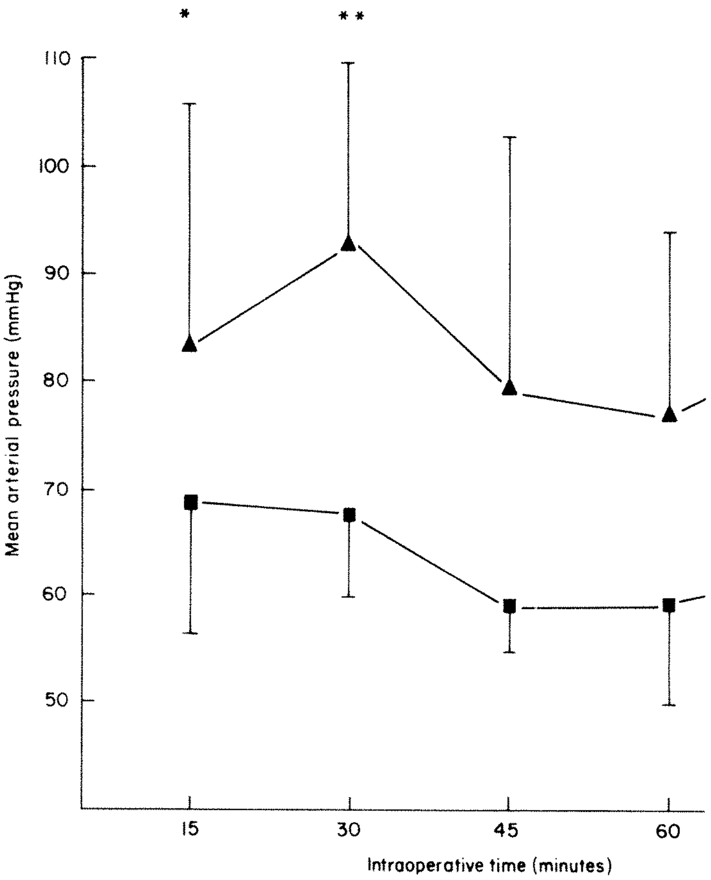

Fig. 1. The intra-operative mean arterial pressures for Group 1 (▲) (general anaesthesia) and Group 2 (■) (epidural analgesia). * $p < 0{\cdot}05$; ** $p < 0.02$ between groups.

and at 30 and 60 minutes postoperatively. Each anaesthetic was administered by the same investigator (G.R.P.).

Group 1. Anaesthesia was induced with thiopentone 5–7 mg/kg and neuromuscular blockade was achieved with alcuronium 15 mg. Ventilation was controlled according to the Radford nomogram[8] to maintain normocapnia, and anaesthesia was maintained with nitrous oxide and isoflurane 0.5–1% in oxygen ($F\text{I}O_2$ 0.3). Neuromuscular blockade was reversed at the end of the procedure with neostigmine 2.5 mg and atropine 1.2 mg.

Group 2. A catheter was introduced into the epidural space at L_{2-3} or L_{3-4} and 16–20 ml of bupivacaine 0.5% was injected into the epidural space. Anaesthesia was then induced with thiopentone 5–7 mg/kg and maintained with nitrous oxide and isoflurane 0.5–1% in oxygen ($F\text{I}O_2$ 0.3) with the patient breathing spontaneously throughout.

Heart rate and mean arterial pressure were recorded for each patient every 5 minutes and immediately before the end of surgery. The duration of surgery and blood loss were also noted.

Blood withdrawn for plasma morphine analysis was placed in siliconised, lithium heparin tubes. The tubes were centrifuged at 3000 rpm for 10 minutes and the supernatant plasma separated and stored at −20°C until analysed. The plasma concentration of morphine at each time point was estimated with two radioimmunoassay techniques (high pressure liquid chromatography with identification of morphine metabolites was not available at the time of study). One method[9] measured the plasma concentration of morphine but crossreacted with morphine-3-glucuronide and morphine-6-glucuronide;[10] this is referred to as crossreacting morphine (CRM).

An extraction procedure before radioimmunoassay in the second method[11] made the assay more specific for unconjugated morphine (UM). Morphine was extracted from the plasma by alkalinisation to pH 9.4 and subsequent addition to the top of a solid phase cartridge (Bond-Elut, C18, Llanbradach, Glamorgan). This was then washed with ammonium acetate buffer and the morphine eluted with methanol. The concentration of morphine in the eluate was measured by radioimmunoassay.[10] The results from this technique correlate well with those from high pressure liquid chromatography. The difference in the results from the two assay methods was taken as an index of the plasma concentration of interfering morphine metabolites (CM). Statistical analysis was performed using an unpaired Student's *t*-test, the Mann–Whitney *U* test or analysis of variance where appropriate.

Results

Details of the two groups are shown in Table 1. There were no significant differences between the ages or weights of the patients in the two groups. Blood loss was significantly lower in Group 2 ($p < 0.05$) and the duration of surgery was longer in Group 1 ($p < 0.05$). The intra-operative mean arterial pressures for the two groups are shown in Fig. 1. The mean arterial pressure of the patients in Group

2 was lower than that of patients in Group 1 throughout surgery and this difference reached statistical significance at 15 and 30 minutes after induction of anaesthesia.

The plasma concentrations of CRM, UM and CM for Groups 1 and 2 are shown in Table 2. Plasma concentrations of UM and CRM rose during the pre-operative period. The levels in Group 1 were higher than those in Group 2 but the difference did not achieve statistical significance. Plasma concentrations of morphine apparently reached a plateau in both groups, within 15 minutes of induction of anaesthesia. Plasma concentrations of UM were always lower than the plasma concentrations of CRM. The modal time to peak plasma concentration of UM was 45 minutes after induction of anaesthesia in Group 1 and 30 minutes after induction of anaesthesia in Group 2. The modal time to peak plasma concentrations of CRM was 45 minutes after induction of anaesthesia in Group 1 and 60 minutes in Group 2. Comparison of Groups 1 and 2 revealed no difference in plasma concentration of UM between the groups. However, there were statistically significant differences between groups in plasma concentration of CRM at 30 and 45 minutes after induction of anaesthesia.

Discussion

Previous pharmacokinetic studies of oral controlled release morphine have been in volunteers or in patients during the pre- or postoperative period;[1,2,5–7,12,13] none has included the intra-operative period. This investigation illustrates the effects of different anaesthetic techniques on the absorption and metabolism of orally administered morphine but similar changes may also be seen after pre-operative oral administration of other agents. The oral administration of morphine may produce metabolites that differ qualitatively or quantitatively from those formed after parenteral administration because of gut wall metabolism.[4,14] Morphine is known to have active metabolites,[15] and these differences may account for the different pharmacodynamic effects of OCRM compared with those of parenterally administered morphine.[4,16]

Table 1. Details of patients in Groups 1 and 2. Values expressed as mean (SD).

	Group 1 ($n = 5$)	Group 2 ($n = 5$)
Age, years	42.6 (4.2)	39.4 (5.0)
Weight, kg	58.7 (6.6)	55.6 (7.8)
Premedication–induction interval, minutes	133.8 (21.0)	129.0 (26.0)
Duration of surgery, minutes	100.6 (19.8)	76.0 (12.0)*
Blood loss, ml	384.0 (270.0)	139.0 (118.0)*

* $p < 0.05$

The effects of surgery and anaesthesia on the absorption and metabolism of drugs administered during the perioperative period are complex. Pre-operative medication with a sedative agent may alleviate anxiety[17] which may in turn alter the absorption of orally administered drugs.[18] It has been observed that stress reduces hepatic blood flow but partially compensates for this by an enhanced intrinsic hepatic clearance of drugs.[19] Anaesthetic agents affect drug absorption and metabolism in a variety of ways and surgery also influences drug metabolism.[20,21] Postoperative investigations have shown that general anaesthesia and surgery which last less than approximately 2 hours are followed by an increase in intrinsic hepatic clearance; there is a decrease after surgery of greater than 4 hours duration. There is no significant effect if surgery is of intermediate duration.[20] In addition, patients who undergo minor surgery under epidural analgesia exhibit increased paracetamol clearance postoperatively.[21]

Two different radioimmunoassay techniques were used in this study to obtain information with regard to the absorption and metabolism of OCRM. One was specific for morphine and indicated the rate of change of morphine concentrations in the systemic circulation. The other used an antiserum which crossreacts with morphine-3-glucuronide at a level of 1–5%[13,14] and morphine-6-glucuronide at 150% relative to morphine (K. Quinn, unpublished observation). There is a relatively low crossreactivity with morphine-3-glucuronide, but this may lead to a significant error when levels are high. Morphine is metabolised primarily by conjugation with glucuronic acid and the metabolites of morphine may contribute significantly to the clinical effect

Table 2. Plasma concentrations (ng/ml) of crossreacting morphine (CRM), unconjugated morphine (UM) and conjugated morphine (CM) for Groups 1 and 2. Values expressed as mean (SD).

	Group 1			Group 2		
Time (minutes)	CRM (ng/ml)	UM (ng/ml)	CM (ng/ml)	CRM (ng/ml)	UM (ng/ml)	CM (ng/ml)
Pre-operative						
0	0	0	0	0	0	0
30	17 (18)	7 (9)	14 (12)	1 (1)	1 (1)	1 (1)
60	49 (42)	9 (10)	41 (34)	22 (7)	4 (3)	18 (6)
90	102 (45)	14 (8)	88 (44)	54 (21)	6 (5)	48 (17)
120	124 (39)	13 (8)	110 (36)	85 (40)	7 (5)	78 (38)
Intra-operative						
15	124 (26)	18 (7)	106 (24)	86 (29)	10 (4)	75 (27)
30	164 (55)	16 (6)	148 (54)	94 (20)*	19 (9)	75 (25)*
45	128 (13)	17 (6)	111 (10)	94 (20)**	16 (4)	79 (19)***
60	123 (10)	16 (8)	106 (11)	117 (37)	11 (3)	106 (35)

* $p < 0.05$; ** $p < 0.02$; *** $p < 0.01$.

CM is not a value for the concentration of morphine metabolites but provides an indication of the amount present.

of the drug. The role of morphine-3-glucuronide has not been elucidated in man but it has no demonstrable analgesic activity in animals; however, morphine-6-glucuronide has potent opioid activity in animals[16] and there is evidence of a similar activity in man.[22,23]

The plasma UM concentrations obtained in this study were apparently lower in Group 2 patients during the pre-operative period. Intra-operatively, they were of the same order and similar to those obtained in other investigations.[1,5,6,12] This suggests that the absorption of OCRM is not altered by different anaesthetic techniques. Plasma morphine concentrations of this level, although low, have been associated with effective analgesia.[1] The plasma CRM concentrations in patients who received general anaesthesia and controlled ventilation were significantly higher 30 and 45 minutes after induction of anaesthesia than those in patients who underwent lumbar epidural analgesia with general anaesthesia. The difference between the groups was because of varying levels of morphine metabolites during this period. The radioimmunoassay method used to detect the metabolites of morphine measures them with differing sensitivities and may even overestimate the plasma concentration of morphine-6-glucuronide. Detailed interpretation of these results is not possible when the relative concentrations of the metabolites are changing. Thus the value given for CM must be interpreted with care and has not been subjected to statistical or pharmacokinetic scrutiny. Similarly, the failure to demonstrate a decrease in plasma UM concentration as plasma CRM concentration increased may reflect the sensitivity of the assay of CRM.

The patients who received epidural analgesia had lower mean arterial pressures then those who did not; this difference was particularly marked at 15 and 30 minutes after induction of anaesthesia and at the end of surgery. Hypotension is a well documented side effect of epidural analgesia but it did not require specific treatment in any patient. Hypotension secondary to haemorrhage results in mobilisation of the splanchnic blood reservoir[24] and mesenteric vasoconstriction.[25] However, the response to spinal anaesthesia may be more complex. Total hepatic blood flow decreases in proportion to the degree of hypotension after epidural blockade[26] but colonic blood flow is maintained during spinal anaesthesia in spite of a significant decrease in mean arterial pressure.[27] This differential response may account for the continued absorption but decreased metabolism of morphine seen in our patients. Surgical stress may have caused some splanchnic vasoconstriction in the patients in Group 1, but maintenance of a normal mean arterial pressure would maintain both hepatic and mesenteric blood flow[28] provided that hypercapnia and hypocapnia were avoided.[29] Normocapnia was maintained during this study; however, hypocapnia occurs commonly during anaesthesia and the effect of this would be to decrease hepatic and mesenteric blood flow, and thereby reduce both absorption and metabolism of orally administered morphine and possibly other drugs.

The two anaesthetic techniques used in this study did not affect the absorption of orally administered morphine. Morphine was metabolised to a lesser extent in the group that received a lumbar epidural and this may be a reflection of the effect of this technique on hepatic blood flow. This may have clinical relevance because at least some of the metabolites of morphine show opioid activity. Further investigation is required to establish the importance of alterations in splanchnic blood flow on the absorption and metabolism of morphine and of other drugs administered orally before surgery. These investigations should be supported by accurate assay techniques for the direct measurement of both the parent drug and its metabolites.

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References

1. Vater M, Smith G, Aherne GW, Aitkenhead AR. Pharmacokinetics and analgesic effect of slow-release oral morphine sulphate in volunteers. *British Journal of Anaesthesia* 1984; **56:** 821–7.
2. Pinnock CA, Derbyshire DR, Elling AE, Smith G. Comparison of oral slow release morphine (MST) with intramuscular morphine for premedication. *Anaesthesia* 1985; **40:** 1082–5.
3. McQuay HJ, Moore RA, Bullingham RES, Carroll D, Baldwin D, Allen MC, Glynn CJ, Lloyd JW. High systemic relative bioavailability of oral morphine in both solution and sustained release formulation. In: *Advances in morphine therapy*. London: Royal Society of Medicine, 1983: 149–54.
4. Park GR. Effect of morphine on gastric emptying. *Anaesthesia* 1985; **40:** 82.
5. Slowey HF, Reynolds AD, Mapleson WW, Vickers MD. Effect of premedication with controlled-release oral morphine on postoperative pain. A comparison with intramuscular morphine. *Anaesthesia* 1985; **40:** 438–40.
6. Park GR, Weir D. A comparison of the effect of oral controlled release morphine and intramuscular morphine on gastric emptying. *Anaesthesia* 1984; **39:** 645–8.
7. Kay B, Healy TEJ. Premedication by controlled-release morphine. *Anaesthesia* 1984; **39:** 587–9.
8. Radford EP, Ferris BG, Kriete BC. Clinical use of a nomogram to estimate proper ventilation during artificial respiration. *New England Journal of Medicine* 1954; **251:** 877–84.
9. Moore RA, Baldwin D, Allen MC, Watson PJO, Bullingham RES, McQuay HJ. Sensitive and specific morphine radioimmunoassay with iodine label: pharmacokinetics of morphine in man after intravenous administration. *Annals of Clinical Biochemistry* 1984; **21:** 318–25.
10. Aherne GW. The specificity of morphine radioimmunoassays. *International Congress Symposia of the Royal Society of Medicine* 1982; **58:** 21–28.
11. Quinn KG, Galloway DG, Leslie ST, Ness C, Robertson S, Schill A. Determination of morphine in human plasma by radioimmunoassay utilising a preliminary liquid/solid extraction. *Journal of Pharmaceutical and Biomedical Analysis* 1988; **6:** 15–22.
12. Leslie ST, Rhodes A, Black FM. Controlled release morphine sulphate tablets—a study in normal volunteers. *British Journal of Clinical Pharmacology* 1980; **9:** 531–4.
13. Fell D, Chmielewski A, Smith G. Postoperative analgesia with controlled-release morphine sulphate: comparison with intramuscular morphine. *British Medical Journal* 1982; **285:** 92–4.
14. Moffat AC. *Clarke's isolation and identification of drugs*. 2nd edn. London: The Pharmaceutical Press, 1986.
15. Shimomura K, Kamato O, Ueki S, Ida S, Oguri K, Yoshimura H, Tsukamoto H. Analgesic effects of morphine glucuronides. *Tohoku Journal Experimental Medicine* 1971; **105:** 45–52.
16. Park GR, Chew SL, Shelly MP. Morpheus revisited. *Anaesthesia* 1985; **40:** 1128–9.
17. Norris W, Baird WLM. Pre-operative anxiety: a study of the incidence and aetiology. *British Journal of Anaesthesia* 1967; **39:** 503–9.

18. Nakano S, Ogawa N, Kawazu Y. Influence of neurotiscism on oral absorption of diazepam. *Clinical Pharmacology and Therapeutics* 1980; **27:** 370–4.
19. Swartz RD, Sidell FR, Cucinell SA. Effects of physical stress on the disposition of drugs eliminated by the liver in man. *Journal of Pharmacology and Experimental Therapeutics* 1974; **188:** 1–7.
20. Pessayre D, Allemand H, Benoist C, Afifi F, Francios M, Benhamou JP. Effect of surgery under general anaesthesia on antipyrine clearance. *British Journal of Clinical Pharmacology* 1978; **6:** 505–13.
21. Ray K, Adithan C, Bapna JS, Kangle PR, Ray K, Ramakrishnan S. Effect of short surgical procedures on salivary paracetamol elimination. *British Journal of Clinical Pharmacology* 1985; **20:** 174–6.
22. Shelly MP, Cory EP, Park GR. Pharmacokinetics of morphine in two children before and after liver transplantation. *British Journal of Anaesthesia* 1987; **58:** 1218–23.
23. Osbourne RJ, Joel SP, Slevin ML. Morphine intoxication in renal failure: the role of morphine-6-glucuronide. *British Medical Journal* 1986; **292:** 1548–9.
24. Greenaway CV. Role of splanchnic venous system in overall cardiovascular homeostasis. *Federation Proceedings* 1983; **42:** 1678–84.
25. Hirsch LJ, Rone AS. Hepatic arterial and portal flow in cardiogenic and hemorrhagic shock in awake dogs. *Circulatory Shock* 1982; **9:** 17–26.
26. Covino BG, Scott DB. *Handbook of epidural anaesthesia and analgesia*. Orlando: Grune and Stratton, 1985: 51.
27. Aitkenhead AR, Gilmour DG, Hothersall AP, Ledingham I McA. Effects of subarachnoid spinal nerve block and arterial $P\text{CO}_2$ on colon blood flow in the dog. *British Journal of Anaesthesia* 1980; **52:** 1071–7.
28. McEvedy BA, Shelly MP, Park GR. Anaesthesia and liver disease. *British Journal of Hospital Medicine* 1986; **36:** 26–34.
29. Corday E, Williams JH. Effect of shock and of vasopressor drugs on the regional circulation of the brain, heart, kidney and liver. *American Journal of Medicine* 1960; **29:** 228–41.

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Recovery and morbidity after daycase anaesthesia

A comparison of propofol with thiopentone–enflurane with and without alfentanil

J. M. MILLAR AND C. F. JEWKES

Summary

The anaesthetic conditions, recovery and side effects for 48 hours postoperatively were compared after anaesthesia for day surgery using propofol or thiopentone–enflurane with and without alfentanil. Propofol provided good conditions for surgery with faster immediate recovery ($p<0.001$); patients who received it were fit for discharge significantly sooner ($p<0.001$). Visual analogue scores of postoperative wellbeing showed an improvement in both propofol groups ($p<0.01$); after thiopentone and enflurane the scores were reduced and took 2 days to return to the pre-operative values. There was a significant ($p<0.001$) reduction in postoperative morbidity in both the groups that received propofol up to 24 hours after discharge. The addition of alfentanil improved anaesthetic conditions and reduced postoperative morbidity with both propofol and thiopentone–enflurane.

Key words

Anaesthesia; daycase.
Anaesthetics, intravenous; propofol, thiopentone.

Economic constraints and bed shortages have encouraged the expansion of day surgery and the Royal College of Surgeons has lent its support.[1] There are undoubted benefits for the patient,[2] but morbidity after day surgery has long been recognised to be a disadvantage.[3–6] No study of postoperative morbidity has demonstrated the best anaesthetic technique for day surgery, and Ogg[2] considered in 1980 that the ideal induction agent had yet to be marketed, and that more research into the most appropriate outpatient anaesthetic was needed.

The recently introduced intravenous anaesthetic agent, propofol, has been shown to have advantages in day surgery over the other available induction agents in the provision of good anaesthetic conditions with more rapid recovery.[7,8] Many studies have commented on the clearheaded nature of the recovery and the low incidence of side effects,[9–11] but few have looked at postoperative morbidity in detail or after the patients' return home. The aim of this present study was to compare the anaesthetic and recovery profile of propofol used for induction and maintenance of anaesthesia for day surgery with that of a standard technique using thiopentone and enflurane. The addition of alfentanil to both techniques was also studied. Postoperative recovery and morbidity was monitored in the Day Surgery Unit until discharge, and by questionnaire for the first 2 days after operation.

Methods

One-hundred-and-thirty patients who presented for elective daycase procedures under general anaesthesia gave informed consent for the single blind study which was approved by the Central Oxford Research Ethics Committee. Patients were aged over 16 years and ASA grade 1 or 2; the procedures lasted 30 minutes or less and did not require tracheal intubation. Those in whom any of the trial drugs were contraindicated or who were taking drugs likely to affect the course of anaesthesia or recovery were not studied.

They were assigned randomly to receive one of four anaesthetics. Group P received propofol titrated to loss of lid reflex, with maintenance bolus doses as required based on clinical judgement. Group TE received thiopentone titrated to loss of lid reflex followed by maintenance with a concentration of enflurane which provided satisfactory operating conditions. Group AP received alfentanil 500 μg followed by propofol induction and maintenance as in Group P. Group ATE received alfentanil 500 μg followed by induction with thiopentone and maintenance with enflurane as in Group TE. All groups received a 2:1 mixture of nitrous oxide and oxygen. Patients breathed spontaneously unless respiration was inadequate, when assisted ventilation was used.

No premedication was given. All patients were induced by way of an indwelling needle in the dorsum of the hand. The ECG was monitored continuously and blood pressure and heart rate pre-operatively and at 5-minute intervals throughout the procedure. Local anaesthetic blocks were used if appropriate. Paracetamol 1 g and metoclopramide 10 mg were prescribed routinely after operation and administered at the discretion of the recovery staff in the usual way. Induction and maintenance were graded as

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Table 1. Comparison of groups: demography and type of surgery.

	Propofol	Thiopentone, enflurane	Propofol, alfentanil	Alfentanil, thiopentone, enflurane
Number of patients	30	33	31	32
Males/females	12/18	11/22	15/16	15/17
Mean age, years (SD)	46 (14.7)	44 (15.3)	48 (15.9)	46 (14.4)
Mean weight, kg (SD)	66 (12.8)	66 (10.0)	69 (10.1)	75 (12.7)
Type of operation				
Minor urology	11	11	16	15
Minor gynaecology	15	16	10	13
Skin incision	4	6	5	4
Duration of operation, minutes (SD)	6.6 (7.5)	5.9 (6.0)	4.6 (5.1)*	8.6 (7.8)*

*$p < 0.005$.

Table 2. Induction and maintenance.

	Propofol	Thiopentone, enflurane	Alfentanil, propofol	Alfentanil, thiopentone, enflurane
Induction				
Dose mg/kg (SD)	2.7 (0.5)	6.3 (0.7)	2.5 (0.4)	5.6 (0.9)
Maintenance				
Propofol, mg/kg/minute	0.4 (0.3)		0.3 (0.3)	
Enflurane, average inspired concentration		3.1 (0.7)		3.0 (0.5)

good, adequate or poor by the anaesthetist and any side effects were noted. The times taken to eye opening on command, obeying a simple instruction and giving the correct date of birth were recorded in the recovery room by staff who were blind to the anaesthetic given.

A single blind assessor recorded the times taken to sit, stand, walk and dress unaided and tolerate oral fluids and food on return to the day surgery unit. These assessments were made every 30 minutes until all had been satisfied; the patient was then deemed fit for discharge and this was verified by an experienced anaesthetist. Side effects were enquired about and recorded. Spontaneous reports of awareness and the administration of analgesics and antiemetics were noted. Each patient was asked, preoperatively and at discharge, to indicated on a 10-cm visual analogue scale how they felt. The extremes of the scale were 'I have never felt worse' and 'I have never felt better'.

Two questionnaires were given to each patient to be completed 24 and 48 hours after discharge, to be returned in a stamped addressed envelope; nonresponders were contacted by telephone. Each was asked to mark a visual analogue scale similar to that used pre- and postoperatively, in addition to recording side effects and behaviour after return home.

Statistical analysis

Data were analysed using the Chi-squared test applied to 2 × 4 contingency tables and Fisher's Exact Test applied to 2 × 2 tables. Duration of operation, recovery times and visual analogue scores were analysed by the Kruskal–Wallis Test when the four treatment groups were compared for overall significance. Pairs of treatments have been compared by the Wilcoxon Rank Sum Test. Recovery times measured to the patients' ability to eat have been analysed by the Gehan–Wilcoxon Test. Tests of significance have been carried out in two stages: the first stage compared the four treatment groups and if the p value was significant at the 5% level, the second stage compared pairs of treatments. The two propofol groups have been considered together where numbers were small, and compared with two thiopentone groups.

Results

Three patients were excluded from the analysis because of protocol violations. A further patient in Group P who was scheduled for cystoscopy and internal urethrotomy developed priapism which made the procedure impossible; he was given ketamine at the surgeon's request in an unsuccessful attempt to reduce this. The operation was abandoned and he has been excluded from the analysis. This has been reported as possible adverse effect of propofol. Four further patients were admitted overnight. Three of these were for surgery that was more major than planned; one patient in the Group TE needed to be admitted overnight because of sleepiness and dizziness. These four have been left in the analysis of postoperative recovery, but excluded from the questionnaire.

Demography (Table 1)

The groups were comparable for sex, age, and weight. The operations were minor gynaecological or urological procedures or minor surgery that involved skin incisions, and were similar for all the groups. The only significant difference in the duration of the operations was between Groups AP and ATE ($p = 0.005$).

Induction and maintenance (Table 2 and Fig. 1)

Differences in the quality of induction between the groups were not significant but only one patient in Groups P and

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Table 3. Recovery in day surgery unit.

	Propofol	Thiopentone, enflurane	Alfentanil, propofol	Alfentanil, thiopentone, enflurane
Time, minutes (SD) from end of operation to				
Eyes open	7.5 (3.4)*	10.7 (5.0)*	5.6 (2.9)*	9.2 (5.8)
Obey command	8.1 (3.5)*	12.1 (5.5)*	6.3 (3.0)*	9.9 (5.8)
Give date of birth	8.6 (3.7)*	12.9 (5.4)*	6.5 (3.1)*	10.6 (6.0)
Sit unaided	35 (11.2)*	59 (36.2)*	35 (16.4)*	40 (20.3)
Able to drink	39 (11.6)*	68 (42.6)*	40 (17.5)*	47 (29.5)
Able to eat	40 (11.8)*	72 (44.7)*	41 (17.4)*	51 (30.8)
Stand unaided	79 (37.6)*	119 (53.3)*	76 (26.7)*	93 (47.8)
Walk unaided	80 (37.5)*	119 (53.5)*	77 (26.7)*	93 (47.8)
Able to dress	90 (53.2)*	133 (60.6)*	82 (26.0)*	104 (49.4)
Fit for discharge	100 (52.6)*	146 (62.8)*	99 (34.0)*	119 (56.2)
Refused food	1§	6§	0§	4§
Analgesics	12 (41%)	11 (33%)	5 (16%)	9 (29%)
Antiemetics	0 (0%)	2 (6%)	0 (0%)	4 (13%)

*$p < 0.001$.
§$p = 0.009$.

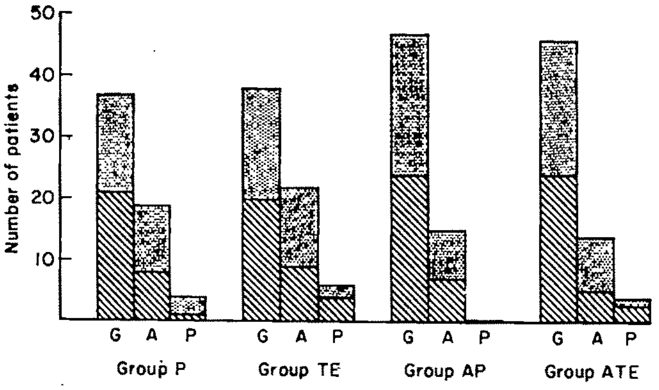

Fig. 1. Quality of induction (■) and maintenance (▨). G, good; A, adequate; P, poor.

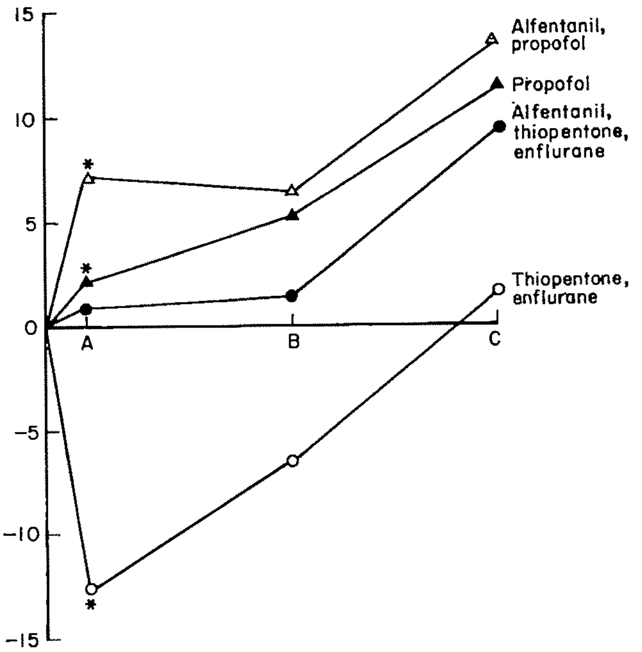

Fig. 2. Visual analogue score; change from admission value. A, at discharge; B, end of first day after operation; C, end of second day after operation. *p, 0.01.

AP had an induction which was graded as poor compared with seven in Groups TE and ATE. Maintenance of anaesthesia was good or adequate in all but six patients, three in Groups P and AP and three in Groups TE and ATE. The addition of alfentanil appeared to improve the quality of maintenance with more patients assessed as good and only one as poor, but this did not reach statistical significance.

Recovery (Table 3)

The times to eyes open, obeying a simple command and giving correct date of birth were significantly shorter in Groups P and AP compared to Group TE ($p < 0.001$). Groups P and AP were able to sit, drink and eat, stand, walk and dress unaided, and were fit for discharge significantly sooner than Group TE ($p < 0.001$). Significantly fewer patients in Groups P and AP (one out of 59) refused food after operation compared with Groups TE and ATE (10 out of 64, $p = 0.009$). No patient in Groups P and AP required antiemetics after operation compared with six in Groups TE and ATE; 14 patients in Groups AP and ATE needed postoperative analgesia compared with 23 in Groups P and TE.

Visual analogue scores (Fig. 2)

The visual analogue scores of general wellbeing at discharge and at 1 and 2 days after operation increased in Groups P and AP, and slightly with ATE compared to admission scores. The score in Group TE took 2 days to return to its pre-operative value. The mean decrease in score at discharge in Group TE was significant ($p < 0.01$) compared with the increase in Groups P and AP.

Postoperative side effects (Table 4)

There was a significant difference between the groups with respect to the total number of patients with side effects ($p < 0.001$), and in the total number of side effects in each group. More patients in Groups TE and ATE complained of side effects, and there were more side effects per patient in these groups. When individual side effects are considered, significantly fewer patients in Groups P and AP complained of drowsiness, dizziness, blurred or double vision, nausea and vomiting and general weakness ($p < 0.001$).

Table 4. Postoperative side effects in day surgery unit.

	Propofol	Thiopentone, enflurane	Alfentanil, propofol	Alfentanil, thiopentone, enflurane
Number of patients	30	33	31	32
Number with side effects	20 (67%)*	28 (88%)*	13 (41%)*	24 (77%)*
Pain at operation site	5	2	0	1
Pain at injection site	0	2	1	3
Depression/crying	0	1	0	1
Drowsiness	11*	18*	2*	16*
Headache	8	11	9	9
Dizziness	3*	15*	3*	4*
Blurred/double vision	0*	8*	0*	4*
General weakness	4*	14*	3*	15*
Vivid dreams	1	3	3	1
Nausea	3*	10*	2*	5*
Vomiting	0*	6*	1*	2*
Muscle aches	1	0	2	0
Sore throat	1	2	0	0
Total side effects	37	92	26	61
Mean number of side effects/patient	1.9	3.3	2.0	2.5

*$p < 0.001$ when propofol groups compared with thiopentone groups.

Table 5. Answers to questionnaires.

	Propofol	Thiopentone, enflurane	Alfentanil, propofol	Alfentanil, thiopentone, enflurane
Questionnaires analysed	26	33	31	32
Felt unwell on way home	0*	6*	1*	3*
Disturbed sleep first night	7	4	1	5
second night	4	5	0	4
Analgesics taken	6	11	8	11
Appetite returned, hours after discharge (SD)	1.6 (1.63)	2.3 (1.58)	1.7 (2.1)	3.2 (6.26)
Meals not taken	2*	13*	2*	8*
Consulted GP	0	4	0	2
Failed to perform everyday tasks	7	9	12	9
First 24 hours				
Felt clumsy first day	4	6	0	4
second day	3	5	0	1
Not back to normal first day	8	15	9	9
second day	4	8	7	6
Back to normal, hours after discharge (SD)	1.3 (2.7)	7.1 (8.3)	7.6 (9.1)	6.2 (8.3)
Fit to go to work, second day	12	11	15	19
No repeat of administered anaesthetic	1	3	0	2

*$p < 0.001$ when propofol groups compared with thiopentone groups.

Questionnaires (Table 5)

There were 122 questionnaires (94%) returned; those from patients who were admitted overnight have been omitted from the analysis. One patient in Group P felt unwell on the way home (largely due to bad driving by father-in-law!) compared to nine in Groups TE and ATE ($p < 0.001$). There were no significant differences in sleep, or requirements for analgesics after operation. Groups P and AP ate sooner after discharge and missed fewer meals. More patients in Group TE felt unwell after the first day after operation; five patients in Groups TE and ATE would not choose a repeat of the anaesthetic compared with only one patient in Groups P and AP. The numbers in each group were too small for tests of significance.

Six patients only consulted their own doctor in the first 2 days after discharge. Reasons where given, were related to the surgery or because the patient had been told to consult his general practitioner by the hospital staff. There were no significant differences in those who did everyday tasks, or felt clumsy the next day; one accident (in Group ATE) was reported, in which a vase was dropped. There was no significant difference in the number of patients who returned to their normal occupation on the second day after operation.

Side effects (Table 6)

Morbidity was similar to that before discharge in the first 24 hours after operation, with more side effects per patient in Groups TE and ATE, although this reached significance only in complaints of drowsiness, dizziness and general weakness ($p < 0.01$). The numbers of patients with side effects by the second day after operation were small but there were still more side effects in Groups TE and ATE.

Table 6. Side effects assessed by questionnaire.

	Propofol		Thiopentone, enflurane		Alfentanil, propofol		Alfentanil, thiopentone, enflurance	
Day after operation	1	2	1	2	1	2	1	2
Number who returned questionnaires	26		33		31		32	
Number with side effects	11 (42%)	11	25 (76%)	13	19 (61%)	11	20 (65%)	13
Pain at operation site	1	2	4	2	0	0	2	1
Pain at injection site	0	0	2	0	2	1	2	0
Drowsiness	7§	2	18§	4	8§	6	11§	6
Headache	2	2	7	6	7	1	6	3
Dizziness	0§	1	9§	3	1§	0	1§	2
Blurred/double vision	0	1	1	0	0	0	0	1
General weakness	7§	5	16§	3	6§	2	14§	4
Vivid dreams	0	1	0	2	0	0	2	0
Nausea	1	2	7	2	3	0	5	3
Vomiting	0	0	0	0	0	0	0	1
Muscle aches	5	4	8	6	9	6	10	8
Sore throat	3	2	2	0	0	0	1	3
Total side effects	26	22	74	28	36	16	54	32
Mean number of side effects per patient	2.4	2.0	3.0	2.2	1.9	1.5	2.7	2.5

§$p < 0.01$.

Discussion

This study investigated immediate and extended recovery after propofol compared with a standard thiopentone–enflurane anaesthetic. Thiopentone was chosen in preference to methohexitone as the latter has been shown to provide less smooth anaesthesia, especially in unpremedicated patients;[8,9,12,13] similar objections apply to etomidate.[12,14] Enflurane was used since halothane is associated with slower recovery[15–17] and considerable postoperative morbidity,[6] and its use in repeat anaesthetics is controversial.[18] Isoflurane is expensive and has been found to be not so suitable for day surgery because of its pungent smell and greater incidence of side effects[13,19] without improvement in recovery.[20] Alfentanil was added to both groups to permit clearer comparison of its effects. It has been shown to decrease the dose of induction agents, improve operating conditions[21] and to have faster recovery with less nausea than fentanyl.[22],[23] It has been used in combination with enflurane to improve the quality of anaesthesia with etomidate[24] and methohexitone.[25]

Fitness for discharge was assessed using Korttila's criteria.[26] Psychomotor recovery after propofol has already been investigated and shown to be faster than methohexitone[7–9] and thiopentone.[7] Questionnaires to assess postoperative morbidity in day surgery patients after discharge have been widely used.[4,5,27] The good induction and maintenance conditions provided by propofol compared with thiopentone were confirmed; had methohexitone been used instead, the conditions produced by propofol would undoubtedly have been superior.[7,10,28] Improved quality of recovery and reduced postoperative morbidity after propofol[8,9,11] were also confirmed. The patients woke more rapidly, were ambulant, able to eat and fit for discharge sooner after propofol. The standard deviation in recovery times was greater with thiopentone, which suggests that recovery from it may be less predictable.

It has been suggested that propofol may have antiemetic properties.[8,29] Nausea and vomiting were reduced in the propofol groups and significantly fewer patients refused food. Interestingly, the addition of alfentanil did not increase nausea and vomiting after propofol and reduced it with thiopentone and enflurane. Subjectively, postoperative wellbeing was strikingly better in those who received propofol; the nursing staff were able to distinguish accurately the patients who had received the drug. This was confirmed by the visual analogue scores: the propofol groups had increased their scores from those found on admission by the time of discharge; those who received thiopentone–enflurane took 48 hours to improve their admission score. Many patients commented that pre-operative apprehension caused them to score lower before operation.

The propofol groups again fared better after discharge. None felt unwell on the way home, fewer meals were omitted, and the reported side effects were reduced significantly in the 24 hours after discharge, particularly with respect to drowsiness, dizziness and general weakness. The differences were less apparent by the second postoperative day. Preference for a repeat of the anaesthetic was greater with propofol.

The place of alfentanil is less clear cut. Recovery times were improved with both propofol and thiopentone–enflurane, although the requirements of these drugs were not reduced significantly. There were fewer side effects and demands for postoperative analgesia were attenuated in both alfentanil groups with no increase in any undesirable side effects apart from apnoea which was easily handled. Clinically it improved the quality of anaesthesia, and it would seem to provide a refinement in day surgery anaesthesia.

In summary, propofol with or without alfentanil provided good conditions for surgery with superior recovery both immediately, and for up to 24 hours after operation. We challenge the opinion expressed[30] that propofol does not have clear advantages over other agents and that thiopentone remains the most appropriate agent for anaesthesia in the majority of cases: we consider propofol to be the present anaesthetic agent of choice for daycase surgery.

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References

1. Royal College of Surgeons of England. *Commisssion on the provision of surgical services—guidelines for day case surgery*. July 1985.
2. Ogg TW. Use of anaesthesia. Implications of day case surgery and anaesthesia. *British Medical Journal* 1980; **281**: 212–4.
3. Fahy A, Marshall M. Postanaesthetic morbidity in outpatients. *British Journal of Anaesthesia* 1969; **41**: 433–8.
4. Towey RM, Stanford BJ, Ballard RM, Gilbert JR. Morbidity of day case gynaecological surgery. A comparison of thiopentone and Althesin. *British Journal of Anaesthesia* 1979; **51**: 453–5.
5. Ogg TW. An assessment of postoperative outpatient cases. *British Medical Journal* 1972; **4**: 573–6.
6. Smith BL, Young PN. Day stay anaesthesia. A follow up of day patients undergoing dental operations under general anaesthesia with tracheal intubation. *Anaesthesia* 1976; **31**: 181–9.
7. MacKenzie N, Grant IS. Comparison of the new emulsion formulation of propofol with methohexitone for induction of anaesthesia in day cases. *British Journal of Anaesthesia* 1985; **57**: 725–31.
8. Kay B, Hargreaves J, Sivalingam T, Healey TEJ. Intravenous anaesthesia for cystoscopy: a comparison of propofol or methohexitone with alfentanil. *European Journal of Anaesthesiology* 1986; **3**: 111–20.
9. O'Toole DP, Milligan KR, Howe JP, McCollum JSC, Dundee JW. A comparison of propofol and methohexitone as induction agents for day case isoflurane anaesthesia. *Anaesthesia* 1987; **42**: 373–6.
10. Cundy JM, Arunasalam K. Use of an emulsion formulation of propofol (Diprivan) in intravenous anaesthesia for termination of pregnancy. A comparison with methohexitone. *Postgraduate Medical Journal* 1985; **3** (Suppl.): 129–31.
11. Johnston RG, Anderson BJ, Noseworthy TW, Shustack A. Diprivan versus thiopentone for outpatient surgery. *Canadian Anaesthetists' Society Journal* 1986; **33**: S106–7.
12. McCollum JSC, Dundee JW. Comparison of induction characteristics of four intravenous anaesthetic agents. *Anaesthesia* 1986; **41**: 995–1000.
13. Short SM, Rutherford CF, Sebel PS. A comparison between isoflurane and alfentanil supplemented anaesthesia for short procedures. *Anaesthesia* 1985; **40**: 1160–4.
14. Sanders RS, Sinclair ME, Sear JW. Alfentanil in short procedures. A comparison with halothane using etomidate or methohexitone for induction of anaesthesia. *Anaesthesia* 1984; **39**: 1202–6.
15. Padfield A, Mullins SRC. Recovery comparison between enflurane and halothane techniques. A study of outpatients undergoing cystoscopy. *Anaesthesia* 1980; **35**: 508–10.
16. Stanford BJ, Plantevin OM, Gilbert JR. Morbidity after day case gynaecological surgery. Comparison of enflurane with halothane. *British Journal of Anaesthesia* 1979; **51**: 1143–5.
17. Storms LH, Stark AH, Calverly K, Smith TN. Psychological functioning after halothane or enflurane anaesthesia. *Anaesthesia and Analgesia* 1980; **59**: 245–9.
18. Blogg CE. Halothane and the liver: the problem revisited and made obsolete. *British Medical Journal* 1986; **292**: 1691–2.
19. Tracey JA, Holland AJC, Unger L. Morbidity in minor gynaecological surgery: a comparison of halothane, enflurane and isoflurane. *British Journal of Anaesthesia* 1983; **54**: 1213–5.
20. Carter JA, Dye AM, Cooper GM. Recovery from day case anaesthesia. The effects of different inhalational anaesthetic agents. *Anaesthesia* 1985; **40**: 545–8.
21. Cooper GM, O'Connor M, Mark J, Harvey J. Effect of alfentanil and fentanyl on recovery from brief anaesthesia. *British Journal of Anaesthesia*, 1983; **55**: 179S–82S.
22. Kay B, Venkataraman P. Recovery after fentanyl and alfentanil in anaesthesia for minor surgery. *British Journal of Anaesthesia* 1983; **55**: 169S–71S.
23. Patrick M, Eager BM, Toft DF, Sebel PS. Alfentanil supplemented anaesthesia for short procedures. A double blind comparison with fentanyl. *British Journal of Anaesthesia* 1984; **56**: 861–5.
24. Collin RIW, Drummond GB, Spence AA. Alfentanil supplemented anaesthesia for short procedures. A double blind study of alfentanil used with etomidate and enflurane for day cases. *Anaesthesia* 1986; **41**: 477–81.
25. Millar JM, Hall PJ. Nausea and vomiting after prostaglandins in day case termination of pregnancy. The efficacy of low dose droperidol. *Anaesthesia* 1987; **42**: 613–8.
26. Korttila K. Full recovery after different anaesthetic techniques for short diagnostic procedures. *Acta Anaesthesiologica Belgica* 1984; **35** (Suppl.): 399–411.
27. Fahy A, Watson BG, Marshall M. Postanaesthetic follow up by questionnaire: a research tool. *British Journal of Anaesthesia* 1969; **41**: 439–41.
28. Valanne J, Korttila K. Comparison of methohexitone and propofol ('Diprivan') for induction of enflurane anaesthesia in outpatients. *Postgraduate Medical Journal* 1985; **61** (Suppl. 3): 138–43.
29. McCollum JSC, Milligan KR, Dundee JW. Has propofol an antiemetic action? *British Journal of Anaesthesia* 1987; **59**: 654P–5P.
30. Editorial. New awakening in anaesthesia—at a price. *Lancet* 1987; **1**: 1469–70.

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Blood pressure response of neonates to tracheal intubation

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Summary

Blood pressure and pulse rate responses to tracheal intubation were studied by oscillotonometric technique in 45 term neonates and 15 infants of similar postconceptual age. No hypertensive response was found in neonates intubated awake and pressures did not differ from those of babies intubated under halothane or after thiopentone and muscle relaxant. The infants did however show a significant increase in systolic and diastolic pressures which indicates that this response may develop after the first month of life.

Key words

Anaesthesia; paediatric.
Intubation tracheal; complications.

Two recent authoritative statements on neonatal anaesthesia have suggested that the traditional practice of 'awake intubation' of neonates may provoke harmful hypertension.[1,2] We are not aware of any study which has demonstrated this. We have therefore investigated blood pressure and pulse rate changes in response to tracheal intubation in neonates and infants presenting for anaesthesia.

Methods

Forty-five neonates and 15 infants were studied during anaesthesia for surgery. Neonatal operations were mainly abdominal. Cardiac surgery and patients with cardiac defects or diaphragmatic hernia were not included. No patient was receiving narcotic, vaso-active or inotropic drugs. Cardiovascular resuscitation when necessary, was completed by volume expansion (plasma) before the study.

Neonates were defined as babies aged 28 days or less. *Infants* (group I) were aged 4 weeks or more. All the neonates studied were born at term (36 weeks or greater) and were aged 1–24 days. Infant ages ranged from 32–93 days. Twelve infants were born at a gestation of 33 weeks or less, and typically presented for inguinal herniotomy or for placement of central venous feeding lines.

The patients were included randomly into equal groups and intubated awake (group A); after N_2O and halothane inhalation (group H); or after thiopentone and atracurium or pancuronium (group T). Pulse rate, systolic and diastolic blood pressures were measured by a Dinamap 847 (Critikon) or Accutor 1A (Datascope) with appropriate-sized cuffs applied to the calf. A measurement was made in all cases immediately before intubation. In group A this was done after a period of pre-oxygenation by mask, in group H when spontaneous movement had ceased and the limbs were flaccid, and in group T about one minute after the relaxant had been given. Another automatic blood pressure cycle was then started as the tube entered the trachea. A resting blood pressure was recorded in 21 neonates and nine infants with the baby in position for induction of anaesthesia but before any manipulations. Intramuscular atropine (45 minutes before operation) was administered to 22 patients (nine in group I, one in group A and 13 in group H).

Statistical methods

Within group comparisons were made with paired Student's *t*-test. Between group comparisons were made by one-way analysis of variance and modified least significant difference test. The level of significance chosen was $p < 0.05$.

Results

The three groups of neonates did not differ in gestational age at birth or weight. The mean age of the halothane group was slightly higher ($p < 0.05$) (Table 1). The mean postconceptual age of the infants was 41 weeks, similar to that of the neonatal group. Blood pressure did not increase in

Table 1. Patient details. Mean (SD) gestational age, weeks; age at study, days; body weight, kg.

Group	Gestation, weeks	Age, days	Weight, kg	*n*
Neonates				
Awake (A)	38.6 (1.8)	4.5 (4.8)	3.05 (0.63)	15
Halothane (H)	39.1 (1.5)	9.2 (8.2)	3.24 (0.56)	15
Thiopentone (T)	39.1 (1.4)	2.8 (1.9)	3.16 (0.58)	15
Infants (I)	31.7 (4.5)	65.5 (20.4)	2.14 (0.51)	15

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Table 2. Mean (SD) pulse rate, beats per minute; systolic and diastolic pressures, mmHg, before and after tracheal intubation. Groups as in Table 1. *n* = number of pairs.

	Before intubation	After intubation	*n*	p value
Systolic pressure				
Group A	76.8 (12.7)	76.2 (8.1)	15	0.842
H	66.7 (13.2)	76.7 (13.3)	15	0.007
T	72.5 (13.9)	72.0 (13.2)	15	0.895
I	77.4 (18.4)	95.1 (13.8)	15	0.003
Diastolic pressure				
Group A	47.3 (9.7)	47.0 (7.43)	15	0.921
H	40.4 (8.1)	46.6 (9.2)	15	0.017
T	46.8 (10.8)	47.3 (10.8)	13	0.898
I	46.5 (18.0)	57.5 (13.7)	15	0.042
Pulse				
Group A	141 (22)	156 (23)	15	0.060
H	163 (22)	174 (16)	15	0.021
T	140 (15)	159 (16)	12	0.000
I	171 (32)	176 (22)	14	0.536

Table 3. Mean (SD) systolic and diastolic pressures (mmHg) before anaesthesia (resting), and after intubation. Members of groups as in Table 1. *n* = number of pairs.

	Resting	After intubation	*n*	p value
Systolic pressure				
Group I	80.8 (12.1)	95.6 (12.1)	9	0.024
H	73.2 (8.1)	77.4 (13.5)	13	0.278
A	76.7 (14.3)	77.0 (9.2)	6	0.920
Diastolic pressure				
Group I	51.1 (14.8)	58.7 (14.6)	9	0.211
H	48.2 (8.0)	47.9 (8.8)	13	0.906
A	45.0 (7.5)	42.8 (5.3)	6	0.459

response to tracheal intubation in the neonates intubated awake (Table 2). There were no differences in blood pressures after intubation between the awake and the two anaesthetised groups. Pulse rate in the awake group did not rise significantly after intubation (Table 2). Significant changes in blood pressures did occur in the halothane group (H) but these followed after values before intubation which were lower (Table 2). Blood pressures in 13 neonates in group H did not differ after intubation from awake resting levels (Table 3).

Resting pulse rates and blood pressures were recorded from nine infants (Table 3). They did not differ from those of the 21 resting neonates. However, in contrast to the neonates, the 15 infants did show significant increases in blood pressures in response to intubation (Table 2), and the systolic pressures were significantly higher than those of the three neonatal groups ($p < 0.05$). This was not because of the use of awake intubation in this group. Systolic pressures increased in all 10 anaesthetised infants (eight halothane and two thiopentone) but in only two of the five intubated awake. In the nine infants with resting values (six halothane and three awake) their blood pressures after intubation were significantly higher (Table 3).

Discussion

Neonatal anaesthetists are currently being encouraged to question, possibly even abandon, the practice of awake intubation[1,2] because of fear that the hypertension produced may predispose to intraventricular haemorrhage (IVH), which is still a major cause of mortality and morbidity in premature babies. The fluctuating pattern of blood pressure seen in sick prematures whose lungs are ventilated without muscle relaxation has indeed been linked with IVH[3] but we know of no published study which relates this to tracheal intubation or anaesthetic practice.

The only paper cited in two recent editorials[1,2] in support of this view neither reports values of blood pressure nor discusses hypertension.[4] Thirty of the 60 premature babies who weighed less than 1500 g and needed respiratory support (> 75% IPPV) were given anticonvulsant doses of phenobarbitone for 7 days in that study.[4] The treated group had a lower incidence of IVH. This appears to be irrelevant to the practice of anaesthesia.

Premature babies, within the first 4 weeks of life, were not included in our study because of the very small number who are presented for anaesthesia without tracheal intubation for resuscititation or intensive therapy. Three such babies presented during the course of our study. All were intubated awake and their mean systolic pressures increased by only 3 mmHg to 72 mmHg at intubation, which confirmed our view that premature babies behave in the same way as the term babies whom we studied. It seems highly unlikely that a hypertensive response should exist in prematures, be absent at term, and be present again after one month as our data suggest. Friesen and Henry[5] in a study of anaesthetic-induced cardiovascular changes report no significant blood pressure increase in 18 prematures intubated awake.

Ideally, our blood pressure data should have been recorded continuously through intra-arterial cannulae, but we did not consider this ethical since cannulation was not clinically indicated. Noninvasive blood pressure measurements were used in previous cardiovascular studies in neonates,[5] and it may be that we may have missed transient hypertension with this system. This is unlikely since the timing of the automated oscillotonometer coincided with the moment that the tube entered the trachea and should have reliably detected any increase in pressure. We know from work in adults that this is triggered by laryngoscopy and lasts 2–3 minutes.[6] Any delayed increase would have been detected by the next determination at one minute after intubation.

The results of our study suggest that a hypertensive response to tracheal intubation is absent at birth but may be present at 1–3 months of age. Our infant group were largely premature at birth so this response seems to relate to postnatal age not postconceptual age. The risk of IVH is very low after 4 weeks of life. In a study of 219 newborns of 32 weeks' gestation or less, who underwent serial ultrasound scans for one month, 48.4% developed periventricular haemorrhage. Time of onset ranged from 1–4 days with a median of 2.[7] Furthermore the magnitude of the increases in pressure in our infants are well within the expected normal range seen with minor procedures such as venepuncture.

Our practice has indeed moved away from awake intubation, but this is because we believe it is unpleasant (but not painful) for the baby and is more difficult for our trainees to perform successfully. Until sound data are presented which show that premature babies do become hypertensive at awake intubation and that this situation is both dangerous for them, and avoidable with anaesthesia, fear of hypertension should not be a reason to avoid awake intubation of any neonate, if this is clinically indicated.

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References

1. EDITORIAL. Pain, anaesthesia, and babies. *Lancet* 1987; **2:** 543–4.
2. BERRY FA, GREGORY GA. Do premature infants require anesthesia for surgery? *Anesthesiology* 1987; **67:** 291–3.
3. PERLMAN JM, MCMENAMIN JB, VOLPE JJ. Fluctuating cerebral blood-flow velocity in respiratory distress syndrome. Relation to the development of intraventricular haemorrhage. *New England Journal of Medicine* 1983; **309:** 204–9.
4. DONN SM, ROLOFF DW, GOLDSTEIN GW. Prevention of intraventricular haemorrhage in preterm infants by phenobarbitone. A controlled trial. *Lancet* 1981; **2:** 215–7.
5. FRIESEN RH, HENRY DB. Cardiovascular changes in preterm neonates receiving isoflurane, halothane, fentanyl and ketamine. *Anesthesiology* 1986; **64:** 238–42.
6. FORBES AM, DALLY FG. Acute hypertension during induction of anaesthesia and endotracheal intubation in normotensive man. *British Journal of Anaesthesia* 1970; **42:** 618–24.
7. SINHA SK, DAVIES JM, SIMS DG, CHISWICK ML. Relation between periventricular haemorrhage and ischaemic brain lesions diagnosed by ultrasound in very pre-term infants. *Lancet* 1985; **2:** 1154–6.

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A comparison of the response of hand and facial muscles to non-depolarising relaxants

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Summary

This study compares the response of the muscles of the hand to those of the face during non-depolarising neuromuscular blockade. It was found that observation of the facial muscles was misleading both in terms of degree of neuromuscular blockade and adequacy of reversal.

Key words

Neuromuscular relaxants.
Measurement techniques; neuromuscular blockade.

The correlation between the response of the hand muscles to those of respiration in relation to the action of non-depolarising muscle relaxants (NMR) is well described.[1] One can expect that the effect of the NMR will have diminished sufficiently, that respiratory function should be adequate and that recurarisation should not occur, if the patient has a sustained response to tetanic stimulation or a train-of-four (TOF) ratio above 0.7. This information was developed using either the flexors of the digits or the adductor of the thumb. The action of NMRs on facial muscles has not been well studied although it has been demonstrated that not all muscle groups respond to NMRs to the same degree.[2] It is necessary in certain surgical situations to have both hands at the side. It is the practice of many anaesthetists in these circumstances, to stimulate the facial nerve and observe the response of the facial muscles to determine both the degree of relaxation achieved and the adequacy of reversal. Our clinical experience suggested that observation of facial muscles does not provide adequate information and a study was designed to test this hypothesis.

Methods

Twenty patients undergoing elective abdominal surgery consented to participate in this protocol approved by our institutional review board. All patients were premedicated with morphine (0.1–0.15 mg/kg) and atropine (0.04 mg/kg) 45–60 minutes before surgery and anaesthesia was induced with thiopentone and isoflurane in 70% N_2O. Tracheal intubation was accomplished aided by suxamethonium and end tidal anaesthetic concentration monitored using a mass spectrometer and maintained within 0.6 of 1.25 MAC. Both the facial and ulnar nerves were stimulated with a train-of-four pattern using separate clinical nerve stimulators. The electromyograph (EMG) was recorded from the thenar eminence (*adductor pollicis* muscle) and one of the facial muscles (either the circumoral or circumorbital muscle groups). Transcutaneous electrodes were used to stimulate nerves and to record the EMG, which was registered on either an ink jet oscillograph or photographed from an oscilloscope trace. Pancuronium was administered in increments to generate a cumulative dose-response curve for each patient. The train-of-four ratio and the T1:T0 ratio were observed in both muscle groups; the anaesthetist was asked to observe both groups and note the occurrence of TOF decrement during onset and reversal of neuromuscular blockade. Values were compared using Student's *t*-test. ($p < 0.05$ was accepted as significant).

Results

Decrement of EMG train-of-four ratio develops in both muscle groups at approximately the same dose ($p > 0.05$) but can be seen much earlier in the muscles of the hand than the facial muscles (see Table 1). There appears to be some increase in the TOF ratio with prolonged block in the facial muscles compared to that in the hand ($p < 0.05$). Train-of-four decrement could not be seen in the facial muscles during reversal at a time when the EMG still

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Table 1. Train-of-four ratio at onset of block. Values are expressed as mean (SD).

	Cumulative dose of pancuronium (mg/kg)				
	0.01	0.015	0.02	0.025	0.03
Face	93.7 (10.6)	72.8 (26.3)	56.7 (23.6)	47.3 (19.4)	22.9 (23.1)
Hand	98.3 (4.4)	77.8 (28.2)	58.7 (26.2)	33.1 (20.5)	20.8 (23.5)

Table 2. Train-of-four ratio at reversal. Values are expressed as mean (SD).

	Time (minutes)			
	0	1	2	3
Face	70.1 (27.5)	82.3 (22.2)	88.3 (20.2)	82.3 (28.2)
Hand	41.2* (30.9)	55.5* (30.5)	56.6* (26.2)	61.0 (24.7)

* $p < 0.05$ hand as compared with face.

indicated that a clinically significant decrement still existed. Train-of-four fade could be noted in the hand muscles both visually and on EMG at the same time (see Table 2).

Discussion

The results of this study support our clinical impression that observation of TOF ratio in the facial muscles gives an erroneous indication of both depth of neuromuscular block and adequacy of reversal when compared to that of the muscles of the hand. The patient will be overdosed with relaxant during the case and inadequately reversed at the end of the procedure if one relies on the facial muscles.

Considerable difficulty has been reported in the evaluation of the TOF response and equally trained observers may evaluate a given T4:T1 ratio differently. We circumvented this in two ways. The same individual simultaneously evaluated the T4:T1 ratio in both muscle groups of the patient; these clinical observations were supported by recordings of their respective TOF ratios.

Various areas of skin may have different electrical resistance, so the stimulus delivered to the nerve was documented as supramaximal to reduce this effect. Differences in skin resistance at the recording site could possibly alter the absolute voltage of the EMG recorded. However, since the TOF ratio was recorded at each site separately and only the ratios were compared, such differences should not have altered the results.

The major physiological differences found between muscle types correspond to a large extent on the relative ratio of fast to slow muscle fibres found in the muscles. The *adductor pollicis* contains approximately 80% type I or slow fibres and the *orbicularis oculi* contains 84% type II or fast fibres.[3] The type I fibres are said to be more sensitive to the action of non-depolarising muscle relaxants.[4,5]

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References

1. Ali HH, Savarese JJ. Monitoring neuromuscular function. *Anesthesiology* 1976; **45:** 216–49.
2. Waud BE, Waud DR. The margin of safety of neuromuscular transmission in the muscle of the diaphragm. *Anesthesiology* 1972; **37:** 417–22.
3. Johnson MA, Polgar J, Weightman D, Appleton D. Data on the distribution of fibre types in thirty-six human muscles. An autopsy study. *Journal of the Neurological Sciences* 1973; **18:** 111–29.
4. Paton WDM, Zaimis EJ. The action of d-tubocurarine and decamethonium on respiratory and other muscles in the cat. *Journal of Physiology* 1951; **112:** 311–31.
5. Secher NH, Rube N, Secher O. Effect of tubocurarine on human soleus and gastrocnemius muscles. *Acta Anaesthesiologica Scandinavica* 1982; **26:** 231–4.

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Sufentanil to supplement nitrous oxide in oxygen during balanced anaesthesia

M. O'CONNOR AND J. W. SEAR

Summary

Sufentanil in doses of 0.4 and 1.0 μg/kg was used as an analgesic supplement to nitrous oxide–oxygen anaesthesia in 28 patients whose lungs were ventilated during body surface or lower abdominal surgery. Significant decreases in arterial blood pressure followed drug administration (mean 35.6%). Decreases in arterial pressure of greater than 30% occurred in 5 out of 14 patients in the low dose group, and 12 out of 14 in the high dose sufentanil group. There was a blunting of the pressor response to laryngoscopy and intubation after sufentanil. Increases in blood pressure were seen in both treatment groups at the onset of surgery. The peak responses were 27% increase in mean arterial pressure in the low dose group, and 51% increase in the 1.0 μg/kg group. There was however no significant change in heart rate. Fourteen patients (8 in the low dose group) required volatile supplementation during surgery for clinical signs of inadequate anaesthesia. This occurred between 21 and 70 minutes after sufentanil administration, and plasma drug concentrations 0.06 and 0.54 ng/ml. Tracheal extubation was successfully achieved at the end of surgery in 26 out of 28 patients at plasma sufentanil concentrations which ranged from 0.03 to 0.37 ng/ml. The two remaining patients, neither of whom had received additional volatile supplementation, required naloxone to overcome postoperative ventilatory depression. No cases of intra-operative awareness were noted.

Key words

Anaesthetic techniques; balanced.
Analgesics, narcotic; sufentanil.

Sufentanil is a potent synthetic pure mu receptor agonist with an elimination half life of about 140 minutes, and a plasma clearance between 12 and 21 ml/kg/minute.[1] The speed of onset of the opioid is faster than fentanyl while its duration of action is similar to that of 7–10 times the dose of fentanyl.[2,3] Most clinical studies to date with the drug have employed doses in the range 5–20 μg/kg, where sufentanil suppresses most haemodynamic and hormonal responses to surgery without significant cardiovascular depression.

Recent studies have shown that sufentanil when given in doses of 0.5–1.0 μg/kg during induction of anaesthesia reduces thiopentone dose requirements and obtunds the responses to laryngoscopy and intubation.[4,5] The studies of Kay and Rolly[2] and Flacke *et al.*[3] have suggested that 0.5–1.0 μg/kg sufentanil as a supplement to nitrous oxide in oxygen has a duration of effect of approximately 40 minutes. Such doses are probably sufficient, within the context of 'British' anaesthesia, for many surgical procedures. We have therefore compared the efficacy, duration of effect, cardiovascular properties and recovery characteristics of two doses of sufentanil, 0.4 and 1.0 μg/kg, as supplement to nitrous oxide in oxygen anaesthesia in patients who underwent abdominal or body surface surgery.

Methods

Twenty eight patients, aged 16–72 years, ASA 1 or 2, were included in the study after they gave their informed consent. The study was approved by the Committee for Safety of Medicines, and the local hospital ethics committee. Patients were all undergoing abdominal or body surface surgery expected to last in excess of 45 minutes, where neuromuscular blockade would normally be part of the anaesthetic procedure. Premedication was with oral diazepam 10–15 mg 1.5 hours before operation. Anaesthesia was induced with a sleep dose of thiopentone, 4–5 mg/kg, and the trachea intubated after neuromuscular blockade with vecuronium 0.1 mg/kg. Anaesthesia was maintained with 67% nitrous oxide in oxygen. The patients were allocated randomly to receive either 0.4 μg/kg or 1.0 μg/kg sufentanil intravenously over 30 seconds once anaesthesia was induced.

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Table 1. Haemodynamic changes during induction of anaesthesia and intubation in patients receiving 0.4 or 1.0 μg/kg sufentanil. Values expressed as mean (SD).

	Awake	After induction	1 minute after laryngoscopy and intubation	Before incision
0.4 μg/kg				
SAP	138.0 (20.5)	106.3 (20.4)*	106.4 (22.1)*	111.4 (21.1)*
DAP	81.3 (12.2)	70.2 (14.7)	74.5 (12.0)	76.1 (18.5)
HR	80.8 (12.2)	77.4 (9.2)	76.4 (13.6)	68.7 (10.4)
RPP	11127 (2383)	8228 (1859)*	8187 (2253)*	7669 (2297)*
1.0 μg/kg				
SAP	135.2 (20.6)	105.0 (20.3)*	90.0 (22.6)*	90.3 (18.2)*†
DAP	81.5 (12.7)	68.4 (14.9)*	59.9 (14.7)*†	61.0 (8.6)*‡
HR	73.9 (9.3)	80.0 (15.4)	70.2 (6.3)	59.2 (10.8)§
RPP	9907 (2240)	8509 (2753)*	6467 (1598)*§	5374 (1522)*†

SAP, systolic arterial pressure; DAP, diastolic arterial blood pressure (mmHg); HR, heart rate (beats/minute); RPP, systolic arterial pressure × heart rate product (mmHg, beats/minute). * $p < 0.01$ within group compared with awake value; † $p < 0.01$ between groups; ‡ $p < 0.02$ between groups; § $p < 0.05$ between groups.

The electrocardiogram (ECG) was monitored continuously using leads in the CM$_5$ configuration during induction of anaesthesia and the surgical period; the pulse rate was derived from the ECG. The arterial blood pressure was recorded with a Copal UA 251 automatic blood pressure monitor before induction, at 2, 5 and 10 minutes after induction, at the time of the surgical incision, and again at 5-minute intervals thereafter until the end of surgery. No volatile supplementation was administered during anaesthesia, unless the patient displayed clinical signs of inadequate anaesthesia (systolic blood pressure more than 20% above the value before the induction of anaesthesia, heart rate greater than 90 beats/minute, sweating, lacrimation, or movement). Under these circumstances, halothane (up to 1.0%) was added to the inspired gas mixture, and the time recorded. Residual neuromuscular blockade was reversed at the end of surgery with atropine and neostigmine, and the time of onset of adequate ventilation and tracheal extubation noted. In cases where depression of ventilation lasted for greater than 15 minutes, and where neuromuscular monitoring using the train-of-four stimulus showed no residual blockade, naloxone 0.1–0.2 mg was administered intravenously. Venous blood samples were collected from a separate cannula in the contralateral arm to determine plasma sufentanil concentrations at the time of the surgical incision, at any time of inadequacy of anaesthesia, and at tracheal extubation. Plasma drug concentrations were measured by radioimmunoassay according to the method of Michiels *et al.*[6] This assay has a sensitivity of 0.02 ng/ml and a coefficient of variation of between 3 and 6% over the concentration range reported in our patients. There is no significant cross-reactivity between sufentanil and any of its presumed metabolites at equimolar concentrations.

Data are shown throughout as the mean (SD); and compared between groups by two-way analysis of variance, Mann–Whitney *U* test, Wilcoxon matched pairs signed ranks test, sign test or Chi-squared test as appropriate.

Results

Twenty-eight patients, 12 female, were studied. Equal numbers of patients received the two dosage regimens. Two patients in the low dose group were receiving beta-adrenoceptor blocking agents for the treatment of hypertension. The mean ages of the two treatment groups were similar: 53.2 (12.6) years [0.4 μg/kg] and 47.8 (14.7) years [1.0 μg/kg]. The duration of anaesthesia varied between 31 and 205 minutes (median for 0.4 μg/kg group, 78.5 minutes; for 1.0 μg/kg group, 87.0 minutes). No patient showed response to the initial surgical incision (plasma concentration range 0.10–0.74 ng/ml for the 0.4 μg/kg group, and 0.19–2.48 ng/ml in the higher dose group). These wide concentration ranges reflect the variable time between induction of anaesthesia and drug administration, and the surgical incision, namely 4–39 minutes, and 5–35 minutes in the two dosage groups respectively. Seventeen patients (nine in the 0.4 μg/kg group) responded during the course of surgery (at plasma concentrations between 0.06–0.54 ng/ml).

The cardiovascular changes seen during induction of anaesthesia are shown in Table 1. The average decreases in mean arterial blood pressure after induction, administration of the bolus of sufentanil and tracheal intubation were significantly different in the 0.4 μg/kg and 1.0 μg/kg sufentanil groups, 30.5 (15.6)% and 40.9 (10.3)% respectively, ($p < 0.001$ compared with awake; $p < 0.02$ between groups). Similar changes were seen for systolic and diastolic arterial blood pressures. The decreases in the heart rate were 16.2 (13.3)% and 19.4 (15.4)% respectively ($p < 0.002$ and 0.012 pre-incision compared with awake values; between groups, NS). The peak heart rate times systolic pressure product (RPP) recorded one minute after laryngoscopy and intubation did not achieve pre-induction levels in either group. There was a significantly lower systolic and diastolic blood pressure and RPP after laryngoscopy and intubation in the 1.0 μg/kg group.

Decreases in mean arterial pressure of greater than 30% occurred in 5 out of 14 patients in the low dose group and 12 out of 14 in the high dose group ($p = 0.025$). In one patient (receiving 0.4 μg/kg) the administration of sufentanil resulted in a marked decrease in blood pressure (161/79 to 41/22 mmHg) coupled with the onset of a slow junctional heart rate (54 beats/minute). This responded promptly to atropine 0.5 mg intravenously with restoration of the blood pressure to 122/90 mmHg. There was a trend in the 0.4 μg/kg group for the blood pressure to return towards the pre-induction values by the time of surgical incision. Immediate increases in mean arterial pressure to

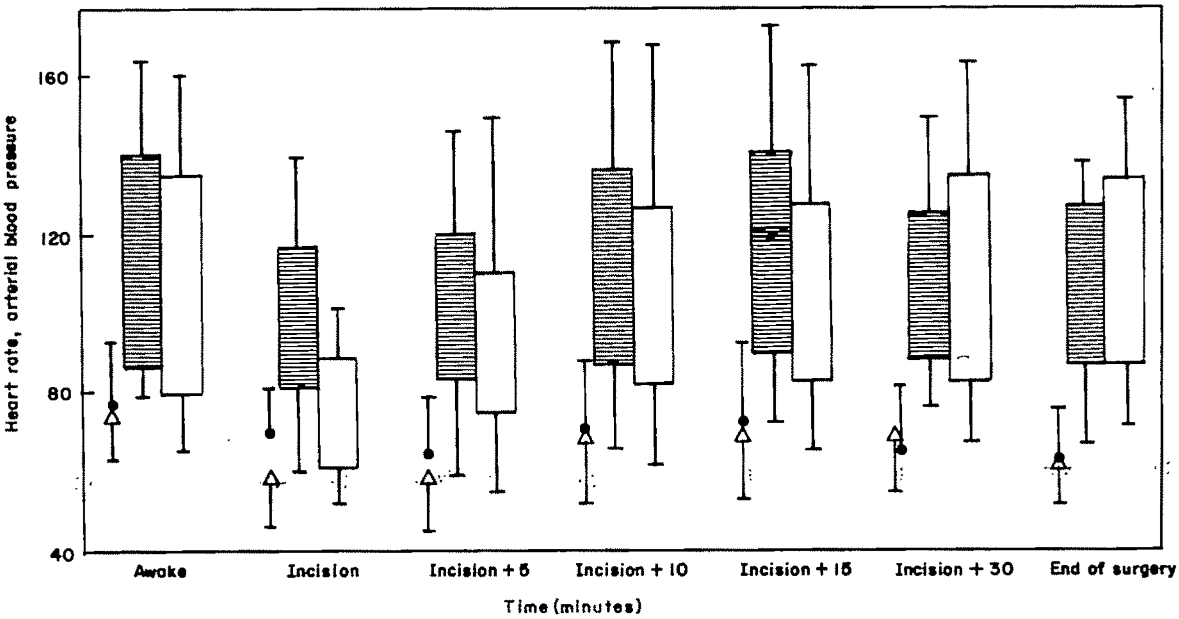

Fig. 1. Haemodynamic changes during maintenance of anaesthesia minutes after the surgical incision. Data shown as mean (SD). Heart rate: ●, low dose group (0.4 μg/kg); △, high dose group (1.0 μg/kg); blood pressure: ■, low dose group; □, high dose group.

greater than 20% above the pre-induction value or a heart rate of greater than 90 beats/minute, were seen after the surgical incision in six patients (four received 0.4 μg/kg sufentanil). The peak increases in mean arterial blood pressure after surgical incision were 26.9% and 51.3% respectively for the 0.4 μg/kg and 1.0 μg/kg groups ($p = 0.002$ and 0.001 as against pre-incision values; NS between groups). There were overall, however, no significant changes in the heart rate during surgery (Fig. 1).

The plasma sufentanil concentration at incision was 0.22 (0.18) ng/ml for the 0.4 μg/kg group (range, 0.10–0.74 ng/ml); and 0.69 (0.60) in the high dosage group (range; 0.19–2.48 ng/ml); the median time to incision was 15 and 20 minutes respectively after sufentanil administration. In eight patients who received 0.4 μg/kg and six 1.0 μg/kg, volatile supplementation was needed at time points between 21 and 46 (mean, 35.5), and 30 and 70 (mean, 52.3) minutes respectively after the onset of anaesthesia (NS). The plasma sufentanil concentration at this time varied between 0.06–0.26 ng/ml. The remaining 14 patients received no supplements for anaesthesia of duration 34–92 minutes in the low dose group, and 45–115 minutes in the high dose group (NS).

Tracheal extubation was successfully achieved in 26 patients. The median times from reversal to extubation were 2 minutes (range, 1–15) for the low dose group, and 3 minutes (2–12) for the high dose group (NS). Recovery to extubation considering all patients together was achieved at 4.3 (2.9) minutes; and 4.5 (3.0) minutes in the 14 patients who did not receive volatile supplementation (NS). The plasma sufentanil concentration at extubation in the 14 patients who required no volatile supplementation ranged between 0.05 and 0.37 ng/ml (median, 0.21 ng/ml).

Two patients, aged 34 and 72 years, one from each treatment group, required naloxone. Neither had received volatile supplementation. The associated plasma sufentanil concentrations were 0.26 and 0.08 ng/ml. No patients displayed delayed postoperative respiratory depression, and there were no cases of awareness during surgery.

Discussion

Balanced anaesthesia is used frequently in clinical practice. Volatile supplementation was needed in 14 out of 28 patients in the present study. For comparison, Flacke *et al.*[3] investigated the properties of four opioids (sufentanil, fentanyl, morphine, and pethidine) in a randomly allocated blinded study, with additional anaesthetic requirements given on the basis of heart rate and blood pressure changes.[3] They used an initial dose of sufentanil of 1.28 μg/kg and gave increments to a total dose of 2.4 μg/kg. In their study, where patients were premedicated with diazepam and droperidol, none required additional use of volatile anaesthesia through failure of adequate control of the heart rate or blood pressure following opioid increments. Nevertheless, their mean time to first supplement (44.1 minutes) was similar to our findings (42.7 minutes); and was comparable with the data of Kay and Rolly.[2] A major difference between our study and that of Flacke *et al.*[3] was the lower incidence of postoperative ventilatory depression which required use of opioid antagonists (7% compared with 41% in the present study). This is undoubtedly because of the lower total opioid dosage given to our patients, where additional anaesthetic supplementation was provided by volatile agents rather than further increments of sufentanil. The incidence of postoperative nausea and vomiting in the present study was less than the 45% incidence quoted by Zuurmond and van Leeuwen[7] in unpremedicated patients who received sufentanil as supplement to nitrous oxide for outpatient arthroscopy.

One of the reported advantages of sufentanil has been cardiovascular and autonomic stability during periods of intensive surgical stimulation.[3,8–11] This was not a significant feature of the present study where 12 out of 28 patients showed significant intra-operative increases in heart rate (more than 90 beats/minute) or blood pressure (> 20% above pre-induction value). However, our doses of sufentanil were one or more orders of magnitude less than these other authors'. In addition, 61% of our patients suffered marked decreases in blood pressure (greater than 30% decrease in mean arterial pressure) after administration of the single dose of sufentanil. This appeared to be a dose-related phenomenon. Whether this incidence would have been reduced by slower drug administration needs to be ascertained.

All opioids cause a decrease in heart rate, thought to be a direct vagotonic effect.[12,13] As a result, there is obtunding of the pressor response to laryngoscopy and intubation. Our data are comparable with those of Kay *et al.*[5] and are in contrast to the exaggerated responses seen when barbiturates especially methohexitone are used alone for induction of anaesthesia.[4,14–16] The peak heart rate–systolic blood pressure product one minute after laryngoscopy and intubation in the present series was 8187 mmHg beats/minute (low dose group) and 6467 mmHg beats/minute (high dose group). This compares with values of approximately 22 000 and 11 000 mmHg beats/minute when methohexitone or propofol alone were used for induction of anaesthesia before laryngoscopy and intubation.[15–17]

The rapidity of recovery from the end of anaesthesia to opening eyes to command and to adequate ventilation was similar in the present study to that reported by Zuurmond and van Leeuwen.[7] This is in keeping with the known kinetic properties of the opioid, a high systemic clearance and short elimination half-life. The wide range of sufentanil concentrations at extubation has not allowed us to define a threshold concentration below which adequate ventilation may be expected. The median plasma sufentanil concentration at extubation in those patients who did not receive volatile supplementation was similar to that reported by Murkin *et al.*[18] and Howie *et al.*[19] after use of sufentanil as the opioid component for cardiac anaesthesia. There are at present no other data with which to compare our study.

For most patients in whom sufentanil is administered as part of a balanced anaesthetic technique with nitrous oxide, with or without volatile supplementation, initial doses of 0.4 μg/kg will suffice. Evidence of clinically inadequate anaesthesia may be corrected by either further opioid increments or increasing the vapour concentration.

References

1. Rosow CE. Sufentanil citrate: a new opioid analgesic for use in anesthesia. *Pharmacotherapy* 1984; **4:** 11–9.
2. Kay B, Rolly G. Duration of action of analgesic supplements to anesthesia. A double-blind comparison between morphine, fentanyl and sufentanil. *Acta Anaesthesiologica Belgica* 1977; **28:** 25–32.
3. Flacke JW, Bloor BC, Kripke BJ, Flacke WE, Warneck CM, van Etten AP, Wong DH, Katz RL. Comparison of morphine, meperidine, fentanyl and sufentanil in balanced anesthesia: a double blind study. *Anesthesia and Analgesia* 1985; **64:** 897–910.
4. Brizgys RV, Morales R, Owens B. Low dose sufentanil: effects on thiopental requirements and hemodynamic response during induction and intubation. *Anesthesiology* 1985; **63:** A377.
5. Kay B, Nolan D, Mayall R, Healy TEJ. The effect of sufentanil on the cardiovascular responses to tracheal intubation. *Anaesthesia* 1987; **42:** 382–6.
6. Michiels M, Hendriks R, Heykants J. Radioimmunoassay of the new opiate analgesics alfentanil and sufentanil. Preliminary pharmacokinetic profile in man. *Journal of Pharmacy and Pharmacology* 1983; **35:** 86–93.
7. Zuurmond WWA, van Leeuwen L. Recovery from sufentanil anaesthesia for outpatient arthroscopy: a comparison with isoflurane. *Acta Anaesthesiologica Scandinavica* 1987; **31:** 154–6.
8. Clark NJ, Meuleman T, Liu W-S, Zwanikken P, Pace NL, Stanley TH. Comparison of sufentanil–N_2O and fentanyl–N_2O in patients without cardiac disease undergoing general surgery. *Anesthesiology* 1987; **66:** 130–5.
9. McKay RD, Varner PD, Hendricks PL, Adams ML, Harsh GR. The evaluation of sufentanil–N_2O–O_2 vs. fentanyl–N_2O–O_2 anesthesia for craniotomy. *Anesthesia and Analgesia* 1984; **63:** 250.
10. Ghoneim MM, Dhanaraj J, Choi WW. Comparison of four opioid analgesics as supplements to nitrous oxide anesthesia. *Anesthesia and Analgesia* 1984; **63:** 405–12.
11. Gauzit R, Marty J, Couderc E, Bouyet I, Flaischler B, Desmonts JM. Comparison of sufentanil and fentanyl with N_2O halothane anesthesia for total hip arthroplasty in elderly patients. *Anesthesiology* 1987; **67:** A120.
12. Robbins BH, Fitzhugh OG, Baxter JH. The action of morphine in slowing the pulse. *Journal of Pharmacology and Experimental Therapeutics* 1939; **66:** 216–23.
13. Liu WS, Bidwai AV, Stanley TH, Isern-Amaral J. Cardiovascular dynamics after large doses of fentanyl and fentanyl plus N_2O in the dog. *Anesthesia and Analgesia* 1976; **55:** 168–72.
14. Forbes AM, Dally FG. Acute hypertension during induction of anaesthesia and endotracheal intubation in normotensive man. *British Journal of Anaesthesia* 1970; **42:** 618–24.
15. Prys-Roberts C, Meloche R, Foëx P. Studies of anaesthesia in relation to hypertension. I: Cardiovascular responses of treated and untreated patients. *British Journal of Anaesthesia* 1971; **43:** 122–37.
16. Prys-Roberts C, Sear JW, Low JM, Phillips KC, Dagnino J. Hemodynamic and hepatic effects of methohexital infusion during nitrous oxide anesthesia in man. *Anesthesia and Analgesia* 1983; **62:** 317–23.
17. Coates DP, Monk CR, Prys-Roberts C, Turtle M. Hemodynamic effects of infusions of the emulsion formulation of propofol during nitrous oxide anesthesia in humans. *Anesthesia and Analgesia* 1987; **66:** 64–70.
18. Murkin JM, Moldenhauer CC, Griesemer RW, Hug CC, Fentanyl vs. sufentanil: comparison of hemodynamic and catecholamine response during coronary artery (CABG) surgery. *Anesthesiology* 1984; **61:** A375.
19. Howie MB, Smith DF, Harrington K, Dasta JF, Reilley TE, Reitz J. Serum concentrations of sufentanil and fentanyl in the postoperative course in cardiac surgical patients. *Anesthesiology* 1984; **61:** A131.

Anaesthesia, 1988, Volume 43, pages 753–754

CASE REPORT

Respiratory failure following envenomation

L. D. KARALLIEDDE AND P. S. SANMUGANATHAN

Summary

Respiratory failure may occur after envenomation. We report our experiences of a patient who required ventilatory care after krait bite. The krait (Bungarus) venom is known to contain bungarotoxins which act at the neuromuscular junction. No cardiac, renal or coagulation disorders were associated with the muscle paralysis after the snake bite. Ventilatory care was easy to institute and was life saving.

Key words

Intensive care; mechanical ventilation, envenomation.
Toxicity; bungarotoxin.

Snake bite (envenomation) is an important cause of morbidity and mortality in tropical countries such as Sri Lanka. Snake venom is also one of the richest biological sources of enzymes, for example pseudocholinesterases, phospholipases, proteases, esterases, hyaluronidases and bradykinin releasing enzymes.[1] Acetylcholine and acetyl cholinesterase are present in many Elapid venoms,[1] which also contain proteins with neurotoxic, cardiotoxic, coagulant and anticoagulant activity. The Elapid krait is of particular interest as the venom contains bungarotoxins, a much used neuropharmacological tool which display neuromuscular blocking properties. A case of envenomation by the Ceylon krait (*Bungarus ceylonicus*) is described.

Case history

A 45-year-old female was bitten at 0130 hours on the left breast whilst asleep indoors. She was referred to Peradeniya Teaching Hospital by a traditional snake bite healer who saw her 3 hours after the bite. She had difficulty swallowing but there was no pain at site of the bite, nor was there any local necrosis. On admission to hospital 6 hours after envenomation she was found to be restless, apprehensive, dyspnoeic and cyanosed. Respiratory rate was in excess of 50 per minute and the tidal volume was 100 ml. She was unable to open her eyes. Immediate tracheal intubation was carried out and mechanical ventilation of her lungs started. There was no requirement for muscle relaxants or related sedatives for intubation, nor was stabilisation on mechanical ventilation necessary. She had generalised paresis with areflexia while ventilation was carried out. Ten vials of Haffkeine Institute antivenin were administered on admission and repeated after 6 hours. Edrophonium 2 mg was administered intravenously during ventilation and there was no change in respiratory or motor functions; a further 10 mg dose was repeated after another 30 minutes, again with no detectable change in motor function. Cardiovascular stability was maintained throughout and the coagulation profile was normal. There was also no evidence of haematuria or other renal dysfunction and cerebrospinal fluid examination was normal.

Forty-eight hours after ventilatory care she showed signs of return of muscle activity and it was possible to wean her off mechanical ventilation after 78 hours. However, she showed signs of residual paralysis of the upper and lower limbs; the distal muscles were more affected than the proximal groups. There was more obvious weakness in the lower than the upper limbs. Serial neurological examinations showed gradual return to normal motor power over 4 weeks.

Discussion

Fayrer in 1872 observed that artificial ventilation abolished cyanosis and convulsions produced by cobra venom in fowls.[2] However, despite over 100 experiments in tracheostomised envenomated dogs, life was prolonged but not saved. Ragotzi in 1890 showed convincingly the peripheral nature of paralysis produced by cobra venom.[3] Since then workers,[4] amidst controversy, confirmed that Elapid venoms produced muscle paralysis which was peripheral in origin.

Headache, vomiting, loss of consciousness, haematuria, haemoptysis, haematemesis, loss of vision and convulsions

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are known preparalytic signs and symptoms after envenomation.[5] Signs of bleeding are peculiar to some Australian Elapid and to viper bites. Observers recorded[6] in the late 19th century that artificial ventilation may be required in the unconscious preparalytic stage. The latent period between bite and development of muscle paralysis has been shown to vary. Paralysis may set in from 45 minutes to 9 hours after envenomation, as a result of bites from Australian and New Guinea Elapids, American coral snakes and kraits, whilst after cobra and mamba bites onset of paralysis has been shorter.[1]

Low concentrations of Formosan cobra *Naja naja atra* venom produced a non-depolarising neuromuscular block similar to the action of curare but its action was only antagonised partially by anticholinesterases.[7] The action of the Formosan krait *Bungarus multicinctus* venom was considered to resemble that of tubocurarine, but was slower in onset; a latent period was always present, and its action was irreversible to washing out and only slightly and incompletely influenced by anticholinesterases. Acetylcholine output was considerably depressed after 20 minutes exposure of the rat diaphragm to the venom.[8]

Muscles are known to vary in their susceptibility to snake neurotoxins and the extrinsic eye muscles are the most susceptible. Mastication, swallowing and tongue muscles may be affected and increase the risk of fluid regurgitation into the nose and aspiration into the lungs, before eye muscle paralysis is complete. Other toxins in Elapid venoms such as coagulant factors and direct or indirect haemolytic factors can cause death during ventilatory care. Reversal of paralysis can take as long as 14 days after cobra bite,[9] 10–12 days after Australian Elapid, one month after Chinese krait and 2 months after Papuan Elapid bite.[10] The paralysis caused by venoms which contain only presynaptic neurotoxins are known to be reversed more rapidly. The amount of tubocurarine required to produce head drop in rabbits after recovery from cobra envenomation is reduced for up to 10 days which indicates residual effects after paralysis.[11]

This patient showed a well defined preparalytic phase with dysphagia as the predominant symptom. The onset of respiratory paralysis was approximately 6 hours after envenomation and the flaccid quadriplegia and areflexia during ventilatory care were characteristic. Edrophonium administered during ventilatory care did not produce any visible change which suggests that the *Bungarus ceylonicus* venom contains bungarotoxins whose predominant effect is not responsive to anticholinesterases. Hemiplegia has been observed after recovery of consciousness following Australian and Papuan Elapid bites and after Sri Lankan viper bites. The peripheral motor neuropathy which followed recovery from respiratory paralysis in this patient is difficult to explain. However, the similarity to the intermediate phase of respiratory failure followed by delayed polyneuropathy with organophosphorus compounds which also act at the neuromuscular junction is striking.[12]

The *Bungarus ceylonicus* venom did not produce any cardiotoxic effects in this patient; there was also no local reaction following the bite and no haemorrhagic or coagulation disorders. However, ventilatory support was life saving. Snake venoms have been used as therapeutic agents in the treatment of chronic pain, terminal cancer, neuralgias, epilepsy and recently as anticoagulants. The potential use of bungarotoxins, which lack cardiotoxic or other systemic effects, as long acting muscle relaxants may be worthy of study.

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References

1. Campbell CH. Snake bite and snake venoms: their effect on the nervous system. In: Vinken PJ, Bruyn GW, eds. *Handbook of clinical neurology II.* Amsterdam: Elsevier, North Holland Biomedical Press, 1979; 1–25.
2. Fayrer J. Treatment of snake poisoning by artificial respiration. *Indian Medical Gazette* 1872; **7**: 218.
3. Ragotzi V. Uber die Wirking des Giftes der Naja tripudians. *Virchows Archives Pathological Anatomy* 1890; **122**: 201–34.
4. Kellaway CH, Holden H. The peripheral action of the Australian snake venoms. I. The curare-like action on frogs. *Australian Journal of Experimental Biology and Medical Science* 1932; **10**: 167–79.
5. Reid HA. Adder bites in Britain. *British Medical Journal* 1976; **2**: 153–6.
6. Garde HC. Notes on three casese of snake bite treated by subcutaneous injections of strychnine. *Australian Medical Gazette* 1890; **9**: 157.
7. Su C. Mode of curare-like action of cobra venom. *Journal Formosan Medical Association* 1960; **59**: 1083–91.
8. Chang CC, Lee CY. Isolation of neurotoxins from the venom of Bungarus multicinctus and their modes of neuromuscular blocking action. *Archives Internationales de Pharmacodynamie et de Thérapie*. 1963; **144**: 241–57.
9. Reid HA. Cobra-bites. *British Medical Journal* 1964; **2**: 540–5.
10. Campbell CH, Young LN. The symptomatology, clinical course and successful treatment of Papuan Elapine snake envenomation. *Medical Journal of Australia* 1961; **1**: 478–86.
11. Schmidt JL, Goodsell EB, Brondyk HD, Kueter KE, Richards RK. The prolonged effect of cobra venom on the sensitivity to d-tubocurarine. *Archives Internationales de Pharmacodynamie et de Thérapie*. 1964; **147**: 569–75.
12. Senanayake N, Karalliedde L. Neurotoxic effects of organophosphorus insecticides. An intermediate syndrome. *New England Journal of Medicine* 1987; **316**: 761–3.

Anaesthesia, 1988, Volume 43, pages 755–756

CASE REPORT

Argyria or cyanosis

A. C. TIMMINS AND G. A. R. MORGAN

Summary

A case of argyria secondary to the prolonged use of nasal drops that contained mild silver protein is presented. The patient was thought to be cyanosed immediately after a total knee replacement. Argyria, its differentiation from cyanosis and its prevention are discussed. The need for a careful drug history is noted.

Key words

Skin; argyria.
Complications; cyanosis.

Argyria is a permanent slate-blue discoloration of the skin, conjunctiva and internal organs that results from long-continued use of products which contain silver. Argyria may closely mimic cyanosis. This paper describes a patient with argyria who presented a diagnostic problem in the immediate period after operation.

Case history

A 68-year-old retired carpenter presented for a total knee replacement for osteoarthritis. He smoked 20 cigarettes per day and had been seen 18 months previously in the Ear, Nose and Throat outpatient department with nasal congestion and chronic sinusitis. Routine clerking was completed by the House Officer and the patient was visited by an anaesthetist on the evening before the operation. The patient was noted to be in good health for his age, with mobility limited only by his knee. No symptoms of cardiovascular or ventilatory disorder were noted and physical examination was reported as normal. The results of preoperative haematological and biochemical investigations were within the normal ranges.

No premedication was prescribed. An intravenous infusion of Hartmann's solution was started on arrival in the anaesthetic room and the patient was sedated with midazolam 4 mg intravenously. Extradural anaesthesia was established with a total of 23 ml of plain bupivacaine 0.5%, administered in divided doses through a catheter at the third lumbar interspace. The block extended from the ninth thoracic to the fifth sacral nerve. The patient lay in the supine position during surgery and breathed oxygen-enriched air (MC mask 2 litres/minute oxygen). An electrocardiogram was displayed and arterial pressure was measured at 5-minute intervals with an automatic non-invasive cuff device. The systolic pressure varied between 120 and 140 mmHg during the operation, and the heart rate between 40 and 80 beats/minute.

The patient was admitted to the Intensive Care Unit for postoperative extradural analgesia; this is routine practice for patients who receive extradural opioids. Nursing staff reported the patient's unusual colour to the Resident Medical Officer. The patient appeared cyanosed at first glance, but on more detailed examination he was noted to have slate-blue discoloration of the fingers, particularly the nail beds, and of the gingival margin of the oral cavity. The tongue and mucous membranes remained pink. The patient was alert, pain-free, had good peripheral perfusion and no signs of dyspnoea. Examination revealed a regular heart rate of 80 beats/minute, arterial pressure of 140/70 mmHg and no elevation of the jugular venous pressure. No cardiac murmurs were noted and his chest was clear on auscultation.

Blood gases sampled while the patient breathed 2 litres/minute of oxygen through an MC mask were pH 7.39, $P\text{CO}_2$ 5.37 kPa, $P\text{O}_2$ 20.8 kPa, bicarbonate 23.9 mmol/litre, and base excess 0.7 mmol/litre. The chest X ray and electrocardiogram were normal. Postoperative haemoglobin was 12.3 g/dlitre with normal cell morphology. The patient received no blood products in the intra- or postoperative periods.

Discussion

Review of the patient's previous notes revealed that he had used Argotone nasal drops each night for 35 years for

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treatment of nasal congestion. Argotone is a nasal decongestant which contains mild silver protein 1% and ephedrine hydrochloride 0.9% in sodium chloride 0.5%. Mild silver protein is used for its antibacterial properties but it is less irritant to sensitive tissues than silver protein because it contains less ionised silver.[1]

Excessive ingestion of medications which contain silver is known to produce argyria, a slate-blue discoloration of the skin and mucous membranes. Silver compounds were used widely for diseases of the nervous system in ancient medicine, in the belief that there was a relationship between silver and the moon, and that the insane were under the influence of lunar deities.[2] The first case of argyria was described in 1791 in a Protestant minister in Hamburg; he had taken silver nitrate for several months for obstructive jaundice and eventually became almost completely black.[3]

Argyria has become less common with the diminished use of medical products which contain silver. Nevertheless, there have been recent case reports of argyria secondary to silver-containing antismoking lozenges,[4] topical silver nitrate,[2] nose drops that contain silver iodide[5] and mild silver protein.[6] The discoloration results from the deposition of silver compounds and metallic silver in the connective tissue. The slate-blue discoloration is more pronounced in areas exposed to light, due partly to stimulation of melanin deposition and partly to photoactivated reduction of silver compounds to metallic silver in the dermis.[4] There is no evidence that it is a cumulative poison.[1] Cyanosis was suspected initially in this case but was excluded because of the absence of cardiorespiratory symptoms or signs, the absence of blanching of the skin on pressure, the pink colour of the tongue and the observation that the blue discoloration was limited to the nail beds and gingival margin. These clinical findings, normal blood gases and the history of medication with silver-containing nose drops for 35 years, led to the diagnosis of argyria.

The slate-blue discoloration of argyria has presented as cyanotic heart disease.[5,6] Other conditions which may produce a dusky, cutaneous discoloration include haemochromatosis, Addison's disease, methaemoglobinaemia and pigmentation because of phenothiazines. Argyria is a benign cosmetic condition. Treatment is rarely successful and requires laborious intradermal injection of the entire area with 6% sodium thiosulphate and 1% potassium ferrocyanide.[6] It can be prevented by avoidance of the long-term use of silver-containing products.

Pulse oximetry was not available at the time of this patient's operation. Subsequent attendance for an unrelated conditon showed an oxygen saturation of 97% using a Physio Control Lifestat 1600 Pulse Oximeter with a finger probe. Arterial blood gases taken simultaneously showed pH 7.34, $P\text{aCO}_2$ 4.7 kPa, $P\text{aO}_2$ 10.2 kPa, bicarbonate 23.4 mmol/litre, base excess −0.1 mmol/litre and calculated oxygen saturation 95.3%. Thus it is unlikely that the blue discoloration has a significant effect on the functioning of a pulse oximeter.

References

1. MARTINDALE. *The extra pharmacopoeia*, 28th edn. London: The Pharmaceutical Press, 1982: 942.
2. MARSHALL JP, SCHNEIDER RP. Systemic argyria secondary to topical silver nitrate. *Archives of Dermatology* 1977; **113:** 1077–9.
3. FOURCROY. M. *La medicine eclairee par les sciences physiques, ou journal des decouvertes relatives aux differentes parties de l'art de guerir*. Paris: Buisson, 1791: No 20, 342–3.
4. MACINTYRE D, MCLAY ALC, EAST BW, WILLIAMS ED, BODDY K. Silver poisoning associated with an antismoking lozenge. *British Medical Journal* 1978; **2:** 1749–50.
5. RICH LL, EPINETTE WW, NASSER WK. Argyria presenting as cyanotic heart disease. *American Journal of Cardiology* 1972; **30:** 290–2.
6. PARKER WA. Argyria and cyanotic heart disease. *American Journal of Hospital Pharmacy* 1977; **34:** 287–9.

Anaesthesia, 1988, Volume 43, pages 757–759

CASE REPORT

Phenytoin-induced resistance to pancuronium

Use of atracurium infusion in management of a neurosurgical patient

D. R. HICKEY, S. SANGWAN AND J. C. BEVAN

Summary

A case report is presented of a patient receiving chronic phenytoin therapy who demonstrated resistance to pancuronium by increased hourly requirements. Stable neuromuscular blockade was achieved by atracurium infusion at normal rates. Possible explanations for the differences in response to the two non-depolarizing muscle relaxants are discussed.

Key words

Anticonvulsant; phenytoin.
Neuromuscular relaxants; pancuronium, atracurium.

Drug interactions may modify the response to neuromuscular blocking drugs. Attention has been drawn recently to resistance to the non-depolarizing relaxants pancuronium, metocurine and vecuronium in patients receiving chronic phenytoin therapy.[1–4] However, atracurium does not appear to be associated with an altered response.[5,6]

This report concerns the management of a neurosurgical patient who demonstrated markedly increased hourly requirements for pancuronium. Continuation of anaesthesia with atracurium by infusion enabled stable neuromuscular blockade to be established and maintained with normal dose requirements of this drug over several hours.

Case history

A 15-year-old male who weighed 72 kg required surgery for excision of a right parietal tumour. Anti-epileptic therapy had started 4 years previously, after a focal seizure at 11 years old. Seizures had been controlled since then by oral phenytoin 350 mg daily. He had no history of drug reactions or allergies and had undergone three uneventful general anaesthetics previously.

Pre-operative physical examination was normal except for decreased visual acuity in the left eye. Normal routine haematological tests and urinalysis were recorded. Phenytoin 150 mg was given orally 2 hours before anaesthesia. Monitoring with electrocardiogram, blood pressure cuff and precordial stethoscope was instituted. Anaesthesia was induced with thiopentone 250 mg and atropine 0.6 mg and tracheal intubation was facilitated by suxamethonium 1.5 mg/kg. Intravenous and arterial lines were established.

Neuromuscular blockade was monitored by train-of-four stimulation of the ulnar nerve, through two superficial electrodes applied to the left forearm with a hand-held stimulator (Bard Biomedical PNS 750). Contraction of the *adductor pollicis* in response to stimulation was assessed visually by observation of thumb movement.

Pancuronium 0.07 mg/kg was administered for relaxation after recovery from suxamethonium. Anaesthesia was maintained with nitrous oxide 66% in oxygen with intermittent positive pressure ventilation to maintain normocapnia. Evoked potential monitoring was planned for surgical localisation of the tumour, so the use of volatile agents, which may interfere with these recordings, was avoided initially and intermittent doses of fentanyl used to supplement anaesthesia.

The initial bolus of pancuronium produced loss of three twitches of the train-of-four. Incremental doses to a total of 0.17 mg/kg in the first hour failed to provide satisfactory relaxation and all four twitches of the train-of-four returned within 10 minutes of each increment. Fentanyl was given in incremental doses to a total of 0.007 mg/kg in the first hour. The addition of isoflurane 0.5–1.5% to the inspired gas mixture was required to supplement relaxation. To obtain a recording of the train-of-four responses, monitoring of neuromuscular function was changed to a Grass stimulator (S48) and force displacement transducer (FT03). Recovery of all four twitches to the same height was evident. Isoflurane was discontinued, to be followed by atracurium, given as an initial bolus of 0.2 mg/kg, and then a continuous infusion delivered through an infusion pump to maintain 95–100% depression of first twitch. Train-of-four monitoring was interrupted periodically to

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allow monitoring of somatosensory evoked potentials in response to stimulation of the right parietal cortex, which necessitated the use of the same monitoring site on the left arm. Dose requirements for atracurium were between 0.26–0.55 mg/kg hour for the next 5 hours 25 minutes of the infusion (Table 1). All four twitches were visible within 16 minutes when the infusion was stopped at the end of surgery and the train-of-four ratio (height of four twitch in relation to the first twitch in the train) was 0.5. Residual neuromuscular blockade was reversed with atropine 1.2 mg and neostigmine 2.5 mg. The return of respiration was rapid and limb movements were vigorous before tracheal extubation, some 25 minutes after the atracurium infusion was stopped.

Table 1. Hourly dose requirements for atracurium infusion for 95–100% neuromuscular blockade.

Time (hour)	Atracurium (mg/kg/hour)
1	0.275
2	0.510
3	0.550
4	0.300
5	0.257
6*	0.278

* Dose for one hour calculated on requirements for 25 minutes of sixth hour of infusion at end of surgery.

Cardiovascular stability was maintained during the period of atracurium infusion, and systolic arterial pressure ranged from 110–130 mmHg and pulse rate from 85–100 beats/minute. Rectal temperature was above 35°C throughout the procedure. The only additional drugs given were decadron 8 mg and mannitol 18 gm. Pathology revealed that the excised right parietal tumour was a calcified venous angioma.

Discussion

This patient appeared to be resistant to the neuromuscular blocking effects of pancuronium on clinical grounds, with increased requirements over the first hour of anaesthesia and a shortened recovery time. An ED$_{95}$ dose of pancuronium of 0.05 mg/kg would allow recovery to 50% return of first twitch height in 37 minutes.[7] However, more than three times the ED$_{95}$ dose given within 60 minutes failed to provide satisfactory relaxation and four twitches of the train-of-four were still present.

It has been shown recently that phenytoin shortens the duration of action of pancuronium by more than 50% in neurosurgical patients[2] and increases requirements by 80%.[1] Similar effects on metocurine requirements[3] were ascribed to pharmacodynamic differences because the plasma concentrations required to maintain 50% block increased after phenytoin. Phenytoin in rats has a dual action, antagonising decamethonium at low dosage and potentiating it at high dosage.[8] Resistance to vecuronium induced by phenytoin has also been reported.[4,6] Carbamazepine, an anticonvulsant drug which is chemically unrelated to phenytoin, has been found to have similar effects on the neuromuscular responses to pancuronium.[9] Serum concentrations of carbamazepine did not correlate with recovery times from pancuronium blockade, which suggested a pharmacodynamic, rather than a pharmacokinetic, explanation.[9]

The mechanism for the resistance to neuromuscular blockers seen in phenytoin-treated patients is unknown. Proposed mechanisms have included: increased metabolism by enzyme induction; decreased sensitivity at the receptor site; an increase in receptor number; or increased end plate anticholinesterase activity.[1] Phenytoin is one of the more potent enzyme-inducing agents.[10] Chronic treatment with phenytoin has been shown to enhance the metabolic elimination of glucocorticoids such as dexamethasone.[11] Pancuronium is metabolised by the liver to a significant degree and has a steroid nucleus.[12] It is conceivable that the pancuronium resistance exhibited by this patient was on the basis of enzyme induction by phenytoin. This patient demonstrated a normal sensitivity to atracurium over a prolonged period of time, although pancuronium requirements were increased. Hourly infusion rates of 0.26–0.55 mg/kg/hour were similar to those previously reported for normal patients[13–19] (Table 2).

The reason for the difference in responses to atracurium and other non-depolarising neuromuscular blocking drugs is unclear. Atracurium does not appear to be antagonised by concurrent phenytoin therapy and dose responsiveness (within the range 0.1–0.25 mg/kg) has been shown to be normal in neurosurgical patients.[5,6] The use of atracurium infusions appear to a reliable clinical option, when predictable relaxation is required for surgery in patients who have received phenytoin pre-operatively.

References

1. Chen J, Kim YD, Dubois M, Kammerer W, MacNamara TE. The increased requirement of pancuronium in neurosurgical patients receiving dilantin chronically. *Anesthesiology* 1983; **59:** A288.
2. Messick JM, Maass L, Faust R, Cucchiara RF. Duration of pancuronium neuromuscular blockade in patients taking anticonvulsant medication. *Anesthesia and Analgesia* 1982; **61:** 203–4.

Table 2. Atracurium infusion rates required for surgical relaxation.

Reference	Age	Anaesthesia	Atracurium mg/kg/hour Mean	Range
11	Children	Narcotic-based	0.56	(0.40–0.82)
		Halothane	0.41	(0.29–0.56)
		Isoflurane	0.35	(0.26–0.56)
12	Adults	Narcotic-based	0.41	(0.34–0.54)
13	Adults	Narcotic/halothane	0.37	(0.29–0.46)
14	Adults	Narcotic-based	0.48	(0.35–0.86)
15	Adults	Narcotic-based	0.59	(0.29–1.01)
16	Adults	Balanced	0.47	(0.29–0.72)
17	Adults	Narcotic-based	0.50	—

3. Ornstein E, Matteo RS, Young WL, Diaz J. Resistance to metocurine-induced neuromuscular blockade in patients receiving phenytoin. *Anesthesiology* 1985; **63:** 294–8.
4. Ornstein E, Matteo RS, Silverberg PA, Scwartz AE. Dose-response relationship for vecuronium in the presence of chronic phenytoin therapy. *Anesthesia and Analgesia* 1986; **65:** S116.
5. Ornstein E, Schwartz AE, Matteo RS, Young WL. Predictability of atracurium effect in phenytoin exposed patients. *Anesthesiology* 1986; **65:** A112.
6. Ornstein E, Matteo RS, Schwartz AE, Silverberg PA, Young WL, Diaz J. The effect of phenytoin on magnitude and duration of neuromuscular blockade following atracurium or vecuronium. *Anesthesiology* 1987; **67:** 191–6.
7. Donlon JV, Ali HH, Savarese JJ. A new approach to the study of four nondepolarizing relaxants in man. *Anesthesia and Analgesia* 1974; **53:** 934–9.
8. Norris FH, Colella J, McFarlin D. Effect of diphenylhydantoin on neuromuscular synapse. *Neurology* 1964; **14:** 869–76.
9. Roth S, Ebrahim ZY. Resistance to pancuronium in patients receiving carbamazepine. *Anesthesiology* 1987; **66:** 691–3.
10. Perucca E, Richens A. Drug interactions with phenytoin. *Drugs* 1981; **21:** 120–37.
11. Haque N, Thrasher K, Werk EE Jr, Knowles HC Jr, Sholiton LJ. Studies on dexamethasone metabolism in man: effect of diphenylhydantoin. *Journal of Clinical Endocrinology and Metabolism* 1972; **34:** 44–50.
12. Miller RD, Agoston S, Booij LHD, Kersten UW, Crul JF, Ham J. The comparative potency and pharmacokinetics of pancuronium and its metabolites in anesthetized man. *Journal of Pharmacology and Experimental Therapeutics* 1978; **207:** 539–43.
13. Brandom BW, Cook DR, Woelfel SK, Rudd GD, Fehr B, Lineberry CG. Atracurium infusion requirements in children during halothane, isoflurane, and narcotic anesthesia. *Anesthesia and Analgesia* 1985; **64:** 471–6.
14. Flynn PJ, Hughes RA, Walton B, Jothilingam S. Use of atracurium infusions for general surgical procedures including cardiac surgery with induced hypothermia. *British Journal of Anaesthesia* 1983; **55:** 135S–8S.
15. Eagar BM, Flynn PJ, Hughes R. Infusion of atracurium for long surgical procedures. *British Journal of Anaesthesia* 1984; **56:** 447–52.
16. Rowlands DE. Simple atracurium infusions. *British Journal of Anaesthesia* 1985; **57:** 542.
17. Wadon AJ, Dogra S, Anand S. Atracurium infusion in the intensive care unit. *British Journal of Anaesthesia* 1986; **58:** 64S–7S.
18. Savarese JJ, Gargarian M, Scott RPF, Embree PB, Ali HH, Basta SJ, Sunder N, Weakly JN, Batson AG. Efficacy of atracurium as a continuous infusion. *British Journal of Anaesthesia* 1986; **58:** 55S.
19. Madsen VJ, Andersen BN, Schurizek BA, Jensen OV, Juhl B. Atracurium administered by infusion for long neurosurgical procedures. *British Journal of Anaesthesia* 1986; **58:** 60S–2S.

Anaesthesia, 1988, Volume 43, pages 760–761

CASE REPORT

Minitracheotomy in children

The management of sputum retention in older children by minitracheotomy

P. W. ALLEN AND S. M. HART

Summary

The successful management of sputum retention by minitracheotomy in two 12-year-old patients is reported. Some advantages and potential problems are discussed. This is the first time that minitracheotomy has been reported in this age group.

Key words

Equipment; tracheostomy.
Complications; bronchial intubation.

Minitracheotomy by way of the cricothyroid membrane provides a means of regular access to the tracheobronchial tree in the management of patients with sputum retention.[1] The technique is a useful alternative in suitable patients to tracheotomy or continuous tracheal intubation. Although the manufacturers of the relevant equipment recommend that the technique should not be used on patients younger than 12 years (Mini-Trach Product Information, Portex Ltd.), the youngest patient treated by Matthews and Hopkinson[1] was aged 19 years. We report the use of minitracheotomy in two 12-year-old children.

Case histories

Case 1

A 12.5-year-old, 32 kg boy was transferred from another hospital with a severe head injury following a road traffic accident. He was deeply unconscious, his trachea was intubated and his lungs were ventilated. Computerised tomography showed a skull fracture in the right frontotemporal region, generalised cerebral oedema with microhaemorrhages and obliteration of the lateral ventricles. There were no other significant injuries. Ventilation was continued electively in the Intensive Care Unit for 5 days as part of a brain protection regimen, and for a further 17 days because of a chest infection and a level of consciousness of between 4 and 7 on the Glascow Coma Scale.

His trachea was extubated after 2 days of spontaneous ventilation with good blood gases. Minitracheotomy was carried out 6 hours later for sputum retention and copious sputum was aspirated. The organisms concerned were *Pseudomonas spp.*, *Staph. aureus* and *H. influenza.* Chest X ray showed that the standard 4.0 mm minitracheotomy tube had intubated the right main bronchus (Fig. 1). The tube was withdrawn 3.5 cm and the split was extended to

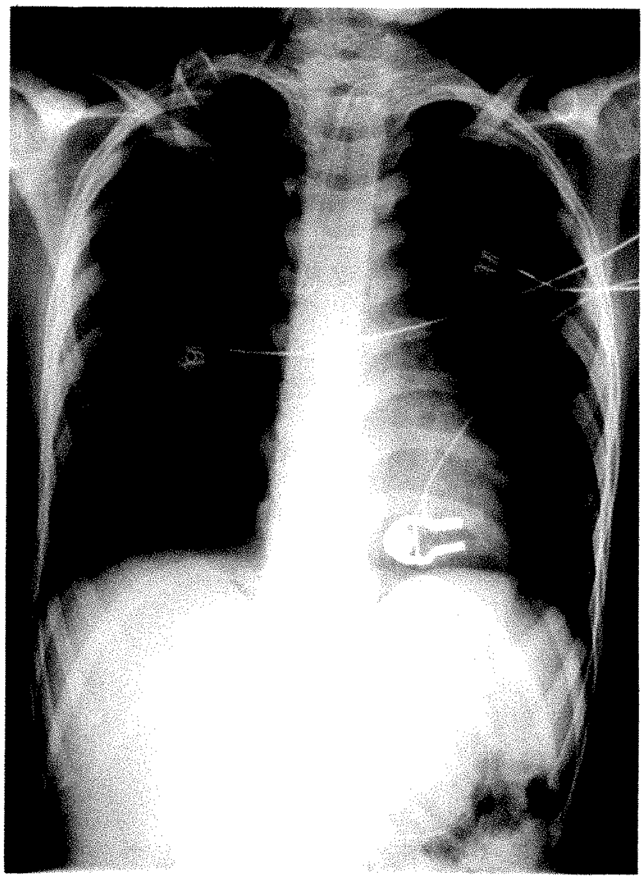

Fig. 1. The chest X ray of the first patient showing the unshortened minitracheotomy tube in the right main bronchus.

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bring the flaps down to the skin. The child's respiratory function continued to improve with suction, antibiotics and physiotherapy and the minitracheotomy was removed after 9 days. The site healed spontaneously.

Nineteen months after the accident, the child has a residual left hemiparesis but can walk independently and ride a bicycle. His speech is normal and he has no respiratory or airway problems.

Case 2

A 12.5-year-old, 35 kg girl was admitted with a fluctuating level of consciousness after a fall from a bicycle. She had hypertonic arms and flaccid legs. Thoracolumbar spine X rays showed a fracture dislocation at T_7/T_8, with 40% anterior dislocation. Computerised tomography of her head showed cerebellar and brain stem contusions.

Major disruption of the lower five thoracic vertebrae was confirmed at operation, and stabilised with Harrington rods. The right pleura was drained and she was returned to the Intensive Care Unit where elective ventilation was continued for 5 days. She developed persistent right upper lobe collapse despite careful humidification, physiotherapy and suctioning. Sputum culture revealed *Staph. aureus.*

She breathed spontaneously through a tracheal tube for the next 7 days and her level of consciousness improved slowly. She became cyanosed and clammy on the twelfth day and was found to have collapse and consolidation of the left upper and lower lobes. Fibreoptic bronchoscopy was performed and mucous plugs were removed, with rapid clinical and radiological improvement. Sputum culture revealed *Pseudomonas spp.* Bronchoscopy was repeated on each of the next 2 days for recurrent right-sided collapse. Her trachea was extubated 15 days after admission, when she was awake, responsive and objecting to the tracheal tube. A minitracheotomy was performed on the following day in the Intensive Care Unit under inhalational anaesthesia with halothane and oxygen. Her condition improved with the aspiration of copious secretions. The return of a strong cough reflex allowed the removal of the minitracheotomy after 10 days.

Twenty months after the accident she has sensory loss to T_8 and a residual paraparesis. She is unable to walk or support herself. Her conscious level and speech are normal and there are no respiratory or airway problems.

Discussion

Cricothyroidotomy is not a new procedure. Chevalier Jackson in 1921[2] condemned it as dangerous and seldom justified. Brantigan and Grow in 1976[3] reported elective cricothyroidotomy in 655 cases, which included 12 children less than 15 years of age who had no apparent long term ill effects; their technique involved the use of a standard tracheostomy tube, and is more formal and less convenient than that reported here. Weymuller and Cummings[4] did encounter a high incidence of airway problems on decannulation when this latter technique of cricothyroidotomy was used after a period of prolonged intubation. Brantigan and Grow[5] state that acute laryngeal pathology should be viewed as a contraindication to cricothyroidotomy. A high incidence of significant and permanent voice changes has also been reported.[6] In contrast, Matthews and Hopkinson[1] did not encounter any airway problems or voice changes in their patients following minitracheotomy. Five of their 24 patients had been intubated previously for an unspecified period.

The incidence of severe laryngotracheal stenosis in children has been increasing over the last 15–20 years in pace with the widespread use of long term tracheal intubation.[7] One of our patients had been intubated for 24 days and the other for 15 days. Both children, who were sent to a busy neurosurgical ward, required continued tracheal intubation for sputum retention. Formal tracheostomy would normally have been employed by us in these circumstances. Tracheostomy is not without its hazards, especially in children;[8,9] the technique of minitracheotomy appeared to provide a reasonable alternative to tracheostomy in both children. Both were able to speak, breathe and cough through the larynx but suctioning was more acceptable and more effective than repeated instrumentation of the upper airway. A spigot was not used and the minitracheotomy tube was left open in both patients to reduce the obstruction to airflow caused by the tube. The children were very happy with the technique after their previous experiences and soon ignored the presence of the tube, which was easily managed by nurses and physiotherapists. The standard minitracheotomy tube must be shortened for children by extending the split in order to prevent bronchial intubation. This is not possible using the later model, which has a flanged tube, and it may be preferable to replace this by a standard 4.0 mm tracheal tube cut to the appropriate length. A chest X ray should be performed after the procedure to check the position of the tube and to exclude a pneumothorax.

Our experiences with these two children confirm that minitracheotomy can be used safely on patients as young as 12 years old even after a period of prolonged tracheal intubation.

References

1. Matthews HR, Hopkinson RB. Treatment of sputum retention by minitracheotomy. *British Journal of Surgery* 1984; **71:** 147–50.
2. Jackson C. High tracheostomy and other errors, the chief causes of chronic laryngeal stenosis. *Surgery, Gynecology and Obstetrics* 1921: **32:** 392–8.
3. Brantigan CO, Grow JB. Cricothyroidotomy: elective use in respiratory problems requiring tracheotomy. *Journal of Thoracic and Cardiovascular Surgery* 1976; **71:** 72–80.
4. Weymuller EA, Cummings CW. Cricothyroidotomy: the impact of antecedent endotracheal intubation. *Annals of Otology, Rhinology and Laryngology* 1982; **91:** 437–9.
5. Brantigan CO, Grow JB. Subglottic stenosis after cricothyroidotomy. *Surgery* 1982; **91:** 217–21.
6. Gleeson MJ, Pearson RC, Armistead S, Yates AK. Voice changes following cricothyroidotomy. *Journal of Laryngology and Otology* 1984; **98:** 1015–9.
7. Cotton RT. Pediatric laryngotracheal stenosis. *Journal of Pediatric Surgery* 1984; **19:** 699–704.
8. Johnson DG, Jones R. Surgical aspects of airway management in infants and children. *Surgical Clinics of North America* 1976; **56:** 263–79.
9. Rogers JH. Decannulation by external exploration of tracheostomy in children. *Journal of Laryngology and Otology* 1980; **94:** 563–7.

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APPARATUS

The antigravity suit in neurosurgery

Cardiovascular responses in seated neurosurgical patients

P. M. BRODRICK AND G. S. INGRAM

Summary

The haemodynamic responses associated with inflation of the antigravity suit (G suit, aviation type) to 8.0 kPa were studied in a series of 40 patients who underwent neurosurgical operations in the sitting position. The study showed statistically significant increases in systolic arterial pressure ($p < 0.005$) and mean central venous pressure ($p < 0.001$) with inflation of the suit. The systolic arterial and mean central venous pressures remained significantly elevated immediately before deflation of the suit at the end of the operation ($p < 0.001$ and $p < 0.005$ respectively). The addition of 0.8–1.0 kPa positive end expiratory pressure during suit inflation was also investigated. A further increase in central venous pressure occurred but this did not achieve statistical significance.

Key words

Complications; hypotension.
Equipment; antigravity suit.

The use of the sitting position for neurosurgical operations is still common in the UK.[1] Fifty-two percent of centres questioned in a survey carried out in 1981 used the sitting position for infratentorial surgery and 31% for cervical laminectomy. It is popular with neurosurgeons because of better access to the posterior fossa, improved venous drainage and excellent spatial orientation.[2] There are two commonly used variations of the sitting position. The patient's hips are flexed and the legs raised towards the horizontal in the semirecumbent position, whilst in the full chair position, the patient sits with the legs dependent. Hypotension, which may be exaggerated by anaesthesia, is among the disadvantages of the sitting position;[3] cardiac output, cardiac index and internal carotid flow decrease when an anaesthetised patient is moved from the supine into the sitting position.[4,5] Venous pooling may be accentuated if the legs are dependent in the full chair rather than horizontal as in the semirecumbent position. Air embolism is another potential hazard, and results from the increased negative venous pressure in the operative field. Veins that pass through relatively rigid structures tend to be held open and allow air to be entrained.[6] The risk is greatest during bone flap removal,[7] but air may enter at any stage during the operation.

It has been suggested that the use of an antigravity suit might be an effective method to prevent postural hypotension and air embolism during neurosurgery when the patient is in the sitting position.[8] We therefore undertook a study of the haemodynamic responses of suit inflation to 8.0 kPa in seated neurosurgical patients.

Methods

Forty consecutive patients whose operation was performed in the sitting position were investigated (Table 1). Children aged under 10 years were excluded because of the impracticality of fitting a suit.

Anaesthetic technique

Anaesthesia was induced with thiopentone 4–5 mg/kg, suxamethonium 1–2 mg/kg was given, the larynx sprayed with 4% lignocaine and the trachea intubated with an armoured latex tracheal tube. Tubocurarine 0.5 mg/kg was given after the return of spontaneous muscle movement. Anaesthesia was maintained with nitrous oxide 50% in oxygen and a volatile agent (initially trichloroethylene 0.2–0.5% in the anaesthetic room, followed by halothane 0.5–1.0% or isoflurane 0.5–1.5%) in the operating theatre. The patient's lungs were ventilated with a tidal volume of 10 ml/kg and a frequency of 12 breaths/minute to achieve an end-tidal carbon dioxide tension ($P\bar{E}'CO_2$) between 3 and 4 kPa. The antigravity suit (Fig. 1) was fitted to the patient in the anaesthetic room just before transfer to the operating theatre.

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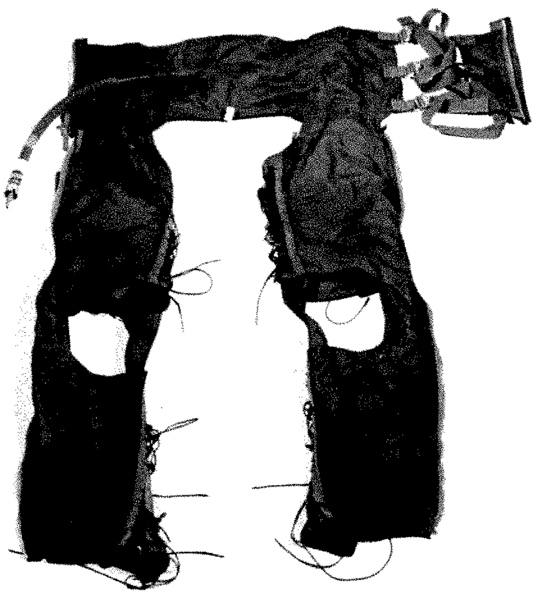

Fig. 1. The antigravity suit.

Table 1. Patient details (n = 40). Values expressed as mean (SEM).

Males	28
Females	12
Age, years	39.8 (2.5)
Weight, kg	69.0 (2.7)

Table 2. Operation details (n = 40). Values expressed as mean (SEM).

Position	
Full chair	12
Semirecumbent	28
Wound height, cm*	12.6 (0.7)
Suit inflation time, minutes	113.3 (6.7)
Fluid infused, ml†	778.3 (59.2)
Fluid loss, ml†	192.3 (24.9)

* n = 19.
† n = 30.

Table 3. Changes in systolic arterial pressure (mmHg). Values expressed as mean (SEM).

Baseline	After inflation	Before deflation	After deflation
All (n = 40)			
94.0	108.6**	115.6¶	104.0*†
(3.7)	(3.1)	(2.9)	(3.1)
Semirecumbent (n = 28)			
93.9	108.4*†	113.5	104.1
(4.9)	(4.1)	(3.5)	(3.7)
Full chair (n = 12)			
94.2	109.2	120.4	103.8†
(5.3)	(4.3)	(5.2)	(6.2)

* $p < 0.05$ (compared to baseline).
** $p < 0.005$ (compared to baseline).
¶ $p < 0.001$ (compared to baseline).
† $p < 0.05$ (compared to the preceding measurement).

Monitoring

Systolic arterial pressure (SAP) was measured with a 20-gauge cannula in a radial artery. Mean central venous pressure (CVP) was measured by a 14- or 16-gauge catheter 60 cm in length. A 3-channel chart recorder was used to record SAP, CVP and $P\text{E}'\text{CO}_2$.

The patient was raised gradually into either the semirecumbent or full chair position, depending on the surgeon's preference. The transducers were then zeroed at the level of the right atrium (RA) for the CVP measurement and at wound height for the arterial pressure. Each measurement of SAP and CVP was made during a period of cardiovascular stability with a minimum of 5 minutes between alterations. The antigravity suit was inflated to 8.0 kPa before surgical preparation of the skin. Positive end expiratory pressure (PEEP) of 0.8–1.0 kPa was added either during skin preparation or after the initial skin incision had been made. PEEP was removed after the dura had been opened and the antigravity suit was normally left inflated until just before reversal of muscle relaxation at the end of the procedure. The time that the antigravity suit was inflated was recorded together with an estimate of the distance between the top of the RA and the base of the wound. The volumes of intravenous fluid administered during the procedure and of blood lost through suction and on the swabs were also noted. Statistical analysis of the haemodynamic measurements was performed using repeated measures analysis of variance (ANOVA) and paired 2-tailed Student's t-test.

Results

The details of the operating positions used, the quantities of fluid administered and blood lost are shown in Table 2. There was a statistically significant increase in SAP after inflation of the antigravity suit compared with baseline ($p < 0.005$) and this rise was maintained during the period of inflation ($p < 0.001$; Table 3). There was no difference between the groups in respect of baseline SAP values before inflation of the suit ($p > 0.9$), or after inflation ($p > 0.9$). The rise in SAP achieved statistical significance ($p < 0.02$) in patients in the semirecumbent position but not in those in the full chair group ($p > 0.05$), probably because of the smaller numbers.

Inflation of the suit resulted in a significant increase in mean central venous pressure ($p < 0.001$), and this increase relative to the baseline value was maintained throughout the operation until deflation (Fig. 2). The initial value of mean CVP after antigravity suit inflation was followed by a small but statistically insignificant decrease before application of PEEP. The addition of 0.8–1.0 kPa PEEP resulted in a small but insignificant increase in mean CVP. Mean CVP decreased slightly, but not significantly during the procedure with the suit inflated and PEEP present. A decrease in mean CVP occurred after the removal of PEEP, although it was not significant. There was no statistically significant change in mean CVP during the period of inflation. There was a decrease in mean CVP ($p < 0.001$) on deflation of the suit but there was no difference between the baseline and post-deflation values ($p > 0.2$). There were no significant differences between the two positions in respect of CVP at any time during the study.

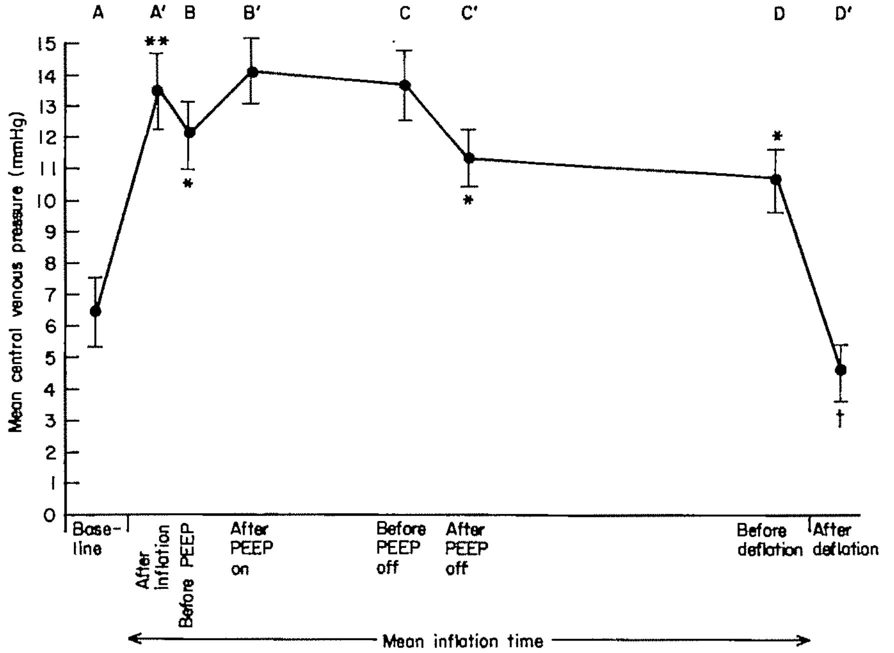

Fig. 2. Changes in mean central venous pressure with inflation/deflation of the antigravity suit and the addition/subtraction of PEEP. Measurements are at 5-minute intervals before and after changes, with the overall timebase indicating the mean inflation time (113 minutes). Bars represent SEM. * $p < 0.005$ compared to baseline; ** $p < 0.001$ compared to baseline; † $p < 0.001$ compared to the preceding measurement. Letters indicate measurements before and after: A–A' inflation of suit; B–B' addition of PEEP; C–C' removal of PEEP; D–D' deflation of suit.

Discussion

A counterpressure suit was advocated first by Crile in 1903 to reduce hypotension in the sitting position.[9] The concept was revived by Gardner and Dohn[10] in 1956, and later by others for neurosurgical practice.[8,11] Blood squeezed from the lower limbs increases the volume above the diaphragm and raises the filling pressure of the right side of the heart.[12,13] Several workers have advocated the use of an antigravity suit to prevent hypotension when the patients are operated upon in the sitting position, but few have studied its cardiovascular effects. The results in this study show a significant increase in SAP with suit inflation, and in particular in patients whose SAP was 85 mmHg or less when placed in the sitting position. In addition, we have confirmed the finding of Auer[13] of a reciprocal relationship between the pre-inflation arterial pressure and the increase in pressure after suit inflation.

Further confirmation of the efficiency of the antigravity suit in maintaining SAP may be found in other published work. Freuchen[14] examined the amounts of intravenous fluid and vasopressor drugs administered to maintain SAP in a series of patients operated on in the sitting position, and wearing the antigravity suit, and compared them with a retrospective series of patients who did not wear the suit. He found that when an inflation pressure of 3.3 kPa was used, the quantities of intravenous fluid and vasopressors used were less in patients who wore the antigravity suit. Martin[11] evaluated a modified antigravity suit of the type used by Gardner[10] in his original study. He found that the suit produced a satisfactory increase in SAP when inflated to 2.7–3.3 kPa in patients who had become hypotensive in the sitting position. There was a decrease in SAP on deflation but this was usually transient. Others have referred to a reactive hyperaemia on deflation,[15] but suit deflation in our patients occurred at the end of the operation and was accompanied by reversal of residual muscle relaxation, lightening of anaesthesia and the return of spontaneous breathing which would have tended to mask any such response, and patients were then returned to the horizontal position.

The ability of the antigravity suit to raise the mean CVP has been demonstrated clearly in these patients. The suit inflation pressure of 8.0 kPa is higher than that used in other published series of sitting neurosurgical patients but derives from Hewer and Logue's work.[8] Higher inflation pressures have been used with the Medical Anti-Shock Trousers (MAST) garment, which is of similar construction and is designed for use in trauma cases.[16] The importance of satisfactory abdominal compression for effective use of the antigravity suit has been shown in aviation medicine[17] and on this basis we have always sought to use the highest possible safe pressure so as to maximise abdominal compression. Prolonged pressure on the abdominal viscera above 8.0 kPa might predispose to ischaemic damage.[8]

Martin[11] used an inflation pressure of 4.0 kPa and found that the initial increase in CVP was not sustained throughout the full period of inflation in all patients. In this series, the mean CVP decreased by only 20% from its postinflation value during a mean inflation time of 113 minutes. It is also interesting to note that the final mean CVP was not significantly different from the baseline value, which suggests that the changes in mean CVP during the procedure are unlikely to have resulted from fluid administration alone. Tinker and Vandam[18] reviewed the use of the antigravity suit in neurosurgical practice and questioned its value. They suggested that the use of the suit may create a problem that the use of the position is trying to avoid, namely increased venous congestion. They claimed that bandaging the legs was a practical alternative to the use of the suit to prevent postural hypotension, but did not support their claim with any experimental data. Freuchen[14] demonstrated that the antigravity suit was more effective than elastic bandages in maintaining cardiovascular stability in sitting patients.

Titration of the venous pressure is possible by the addition or subtraction of PEEP and adjustment of the inflation pressure of the antigravity suit to accommodate both anaesthetic and surgical requirements. The overall increase in mean CVP produced by this combination in our study was the equivalent of 1.2 kPa, which approximates to the pressure exerted by the column of blood between the wound and the right atrium; the mean vertical height between wound and right atrium in 19 patients was approximately 12.5 cm.

The antigravity suit is tedious to apply to an anaesthetised patient, although with practice application can be achieved in less than 5 minutes. However, it affords good control of postural hypotension in the sitting position. In addition, the increase in mean CVP that it produces may be valuable in preventing air embolism.

References

1. Campkin TV. Posture and ventilation during posterior fossa and cervical operations. Current practice in the United Kingdom. *British Journal of Anaesthesia* 1981; **53:** 881–3.
2. Martin JT. *Positioning in anasthesia and surgery*. Philadelphia: W.B. Saunders, 1978: 44–79.
3. Marshall WK, Bedford RF, Miller ED. Cardiovascular responses in the seated position—impact of four anesthetic techniques. *Anesthesia and Analgesia* 1983; **62:** 648–53.
4. Dalrymple DG, MacGowan SW, Macleod GF. Cardiorespiratory effects of the sitting position in neurosurgery. *British Journal of Anaesthesia* 1979; **51:** 1079–81.
5. Tindall GT, Craddock A, Greenfield JC. Effects of the sitting position on blood flow in the internal carotid artery of man during general anesthesia. *Journal of Neurosurgery* 1967; **26:** 383–9.
6. Young ML, Smith DS, Murtagh F, Vasquez A, Levitt J. Comparison of surgical and anesthetic complications in neurosurgical patients experiencing venous air embolism in the sitting position. *Neurosurgery* 1986; **18:** 157–61.
7. Albin MS, Babinski M, Maroon JC, Jannetta PJ. Anaesthetic management of posterior fossa surgery in the sitting position. *Acta Anaesthesiologica Scandinavica* 1976; **20:** 117–28.
8. Hewer AJH, Logue V. Methods of increasing the safety of neuroanaesthesia in the sitting position. *Anaesthesia* 1962; **17:** 476–81.
9. Crile GW. *Blood pressure in surgery: experimental and research*. Philadelphia: J.B. Lippincott Company, 1903: 288.
10. Gardner WJ, Dohn DF. The antigravity suit (G-suit) in surgery. Control of blood pressure in the sitting position and in hypotensive anesthesia. *Journal of the American Medical Association* 1956; **162:** 274–6.
11. Martin JT. Neuroanesthetic adjuncts for surgery in the sitting position: II The antigravity suit. *Anesthesia and Analgesia* 1970; **49:** 588–93.
12. Eich RH, Smulyan H, Chaffee WR. Hemodynamic response to G-suit inflation with and without ganglionic blockade. *Aerospace Medicine* 1966; **37:** 247–50.
13. Auer L. Anti-Gravitationsanzug gegen akuten Blutdruckabfall bei Operationen in sitzender Lagerung. *Acta Neurochirurgica* (Wien) 1976; **32:** 131–7. The use of the 'anti-G-suit' during operations in the sitting position as a treatment of postural hypotension. (English title.)
14. Freuchen IP. The use of an anti-gravity suit in neurosurgery. *Acta Anaesthesiologica Scandinavica* 1959; **3:** 17–23.
15. Gray S, Shaver JA, Kroetz FW, Leonard JJ. Acute and prolonged effects of G suit inflation on cardiovascular dynamics. *Aerospace Medicine* 1969; **40:** 40–3.
16. Butson ARC. Clinical use of antishock trousers. *Canadian Medical Association Journal* 1983; **128:** 1428–30.
17. Wood EH, Lambert EH. Some factors which influence protection afforded by pneumatic anti-g suits. *Journal of Aviation Medicine* 1952; **23:** 218–28.
18. Tinker JH, Vandam LD. How effective is the G suit in neurosurgical operations? *Anesthesiology* 1972; **36:** 609–11.

Anaesthesia, 1988, Volume 43, pages 766–769

APPARATUS

The Downs' adjustable flow generator

G. C. FISHER

Summary

A venturi powered device for the generation of continuous positive airways pressure has been assessed. Some of its functional characteristics appear to be ideal, but the oxygen concentration and adequacy of flows require checking after each adjustment. A positive pressure relief valve and an inlet valve are necessary for the safe use of the system and an airway pressure monitor is recommended.

Key words

Equipment.
Ventilation; continuous positive pressure.

Continuous positive airway pressure (CPAP) during spontaneous breathing can improve the arterial oxygenation of the patient being weaned from mechanical ventilation, but full benefit can only be realised if no additional mechanical work is required to breathe through the apparatus. The workload will be extended if the airway pressure (P_{aw}) increases during expiration or decreases during inspiration. The ideal CPAP system maintains the P_{aw} constant throughout the respiratory cycle, despite the variation in gas flow, provides minimal inspiratory and expiratory flow resistance, and permits the use of a full range of pressures and oxygen concentrations (CPAP, 0.25–2.0 kPa, $F\text{IO}_2$, 0.2–1.0).

Gas flow within a CPAP system can be either continuous or intermittent. Typically, an intensive care ventilator opens a demand flow valve in response to an inspiratory effort. This results in economical gas consumption (fresh gas flow = minute volume), but considerably more inspiratory work is required than if the patient breathes from a valveless continuous flow system;[1] a valveless system must supply fresh gas at flows which exceed the patient's peak inspiratory flow (PIF). These high flows are usually achieved by mixing compressed air and oxygen in a blender. The Downs' adjustable $F\text{IO}_2$ flow generator, however, is powered by the oxygen supply alone; no additional source of compressed air is required because atmospheric air is entrained by a venturi.

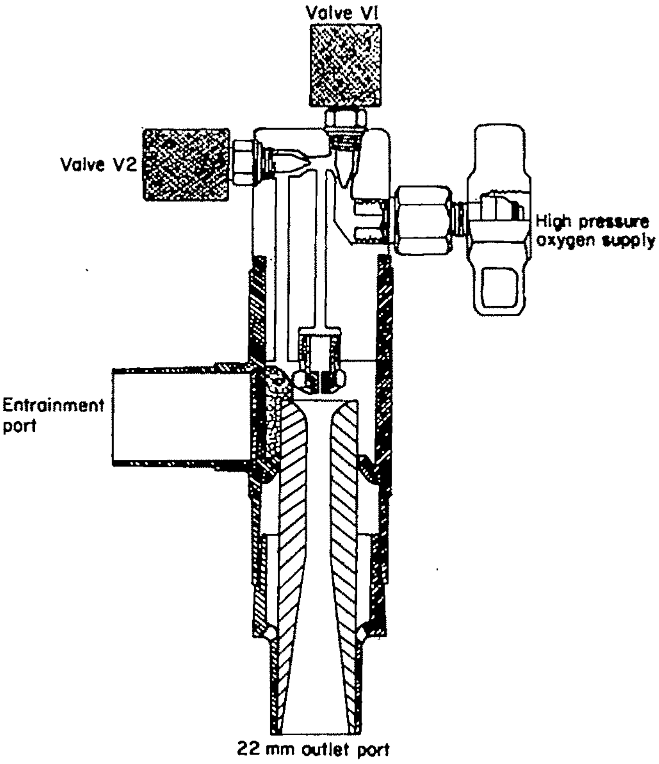

Fig. 1. The Downs' adjustable flow generator.

Description

A prototype venturi device for the administration of CPAP was described by Fried *et al*;[2] a commercially produced version is now available (Vital Signs Inc., Totawa, New Jersey, USA). The device is connected to the oxygen supply by a Schraeder probe (although this can be unscrewed to reveal a nonspecific fitting). Oxygen flows into the venturi when the valve V1 is turned anticlockwise, thus room air is entrained through a one-way valve. This is made of soft

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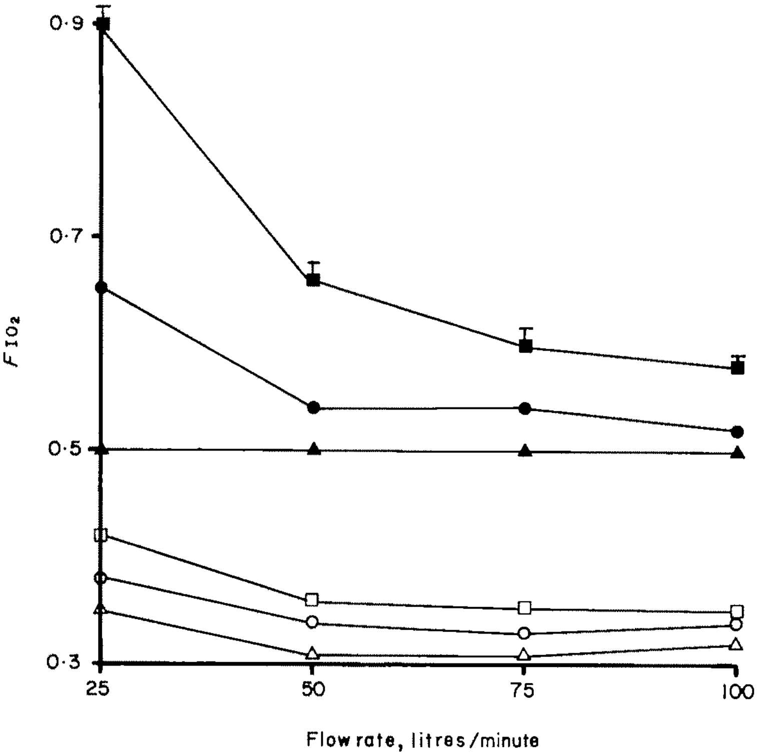

Fig. 2. The mean (SD) influence of flow on gas composition at two settings of valve V2; △, □ and ○, fully closed; ▲, ■, ●, set to deliver an F_{IO_2} of 0.5 from a starting flow of 50 litres/minute at zero pressure. All tests were performed at three levels of CPAP: △, ▲ = 0; ○, ● = 0.5; □, ■ = 1.0 kPa, $n = 6$.

rubber and is only a push fit into the entrainment port. Turning the valve V2 anticlockwise allows a bypass flow of oxygen to enrich the gas mixture, which issues from the 22-mm outlet port. The flow can be conducted through lightweight disposable breathing tubes to a humidifier before being presented to the patient's T-piece. Gas is subsequently vented to the atmosphere by an expiratory valve. A range (0.25, 0.5, 0.75, 1.0, 1.25, 1.5 and 2.0 kPa) of disposable CPAP valves are produced by the same firm. These are an interesting form of threshold resistor using a Euler buckling spring.

Methods

The range of flows and oxygen concentrations produced by six flow generators were assessed in the laboratory. Each one was fitted with a bacterial filter (Pall) on the entrainment port and attached to the piped oxygen supply. Using disposable breathing hose, they were connected to a humidifier (Cape 955, 273) filled to the 'maximum' line with water, and then to a CPAP valve (Vital Signs Inc.). The humidifier and filter simulated conditions in the ICU, although the humidifier was not switched on, so that gas flows and composition could be measured at room temperature. Gas composition, immediately before the humidifier was measured with a fuel cell oxygen analyser, calibrated on room air and on pure oxygen. Gas flows were measured with a pneumotachograph which consisted of a flow sensor (Fleisch #2) connected to a transducer (Statham) the output of which was amplified and recorded (Grass Polygraph). This was calibrated against a precision flowmeter (GEC Elliot) using air at room temperature. The flows were adjusted for the effect of gas composition on the pneumotachograph using a graph (see Appendix); pressures were measured immediately proximal to the expiratory valve with a Statham transducer. All recordings were made after readings had stabilised for 2 minutes.

The maximum and minimum F_{IO_2} and flows were measured. Maximal airway pressures with the CPAP valve outlet occluded were recorded, since this condition could theoretically arise with the system connected to a patient.

Two further sets of tests were carried out. The first studied the influence of flow on gas composition at three levels of CPAP (0, 0.5 and 1.0 kPa). Two settings of the valve V2 were chosen: fully closed, to deliver the minimum F_{IO_2}; and set to deliver an F_{IO_2} of 0.5 from a starting flow of 50 litres/minute at zero pressure. The change in F_{IO_2} which resulted from an increase in the flow from 25 to 100 litres/minute was recorded with 0.5 and 1.0 kPa expiratory valves. The second looked at the effect of increasing back pressure on the venturi by setting the six units to produce an F_{IO_2} of 0.5 at 50 litres/minute at 0.5 kPa CPAP. The flow and oxygen concentration were measured, maintaining these valve settings, with CPAP valves rated at 0, 0.25, 0.5, 0.75 and 1.0 kPa pressures.

Results

The maximum F_{IO_2} of 1.0 was obtained with valve V2 fully open. The minimum F_{IO_2} obtainable proved to be 0.31 against the back pressure of the humidifier alone, but this increased to 0.35 at 1.0 kPa CPAP. Throughout the full range of available oxygen concentrations, flows could be continuously varied between 0 and > 100 litres/minute (the

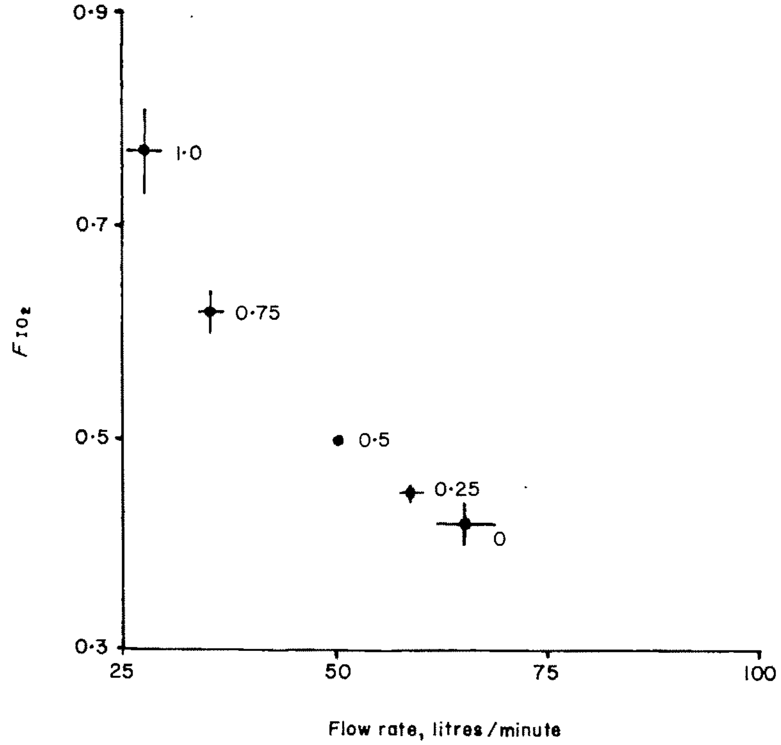

Fig. 3. The mean (SD) effect of increasing CPAP (0.25, 0.5, 0.75, 1.0 kPa) on gas flow and composition, $n = 6$.

range of the pneumotachograph used) into all of the loads provided by the humidifier and valves under test. Figure 2 shows the variation of oxygen concentration with flow set constantly at valve V2. The $F\text{IO}_2$ was independent of flow at high flows, but strengthened as the flow decreased towards 25 litres/minute. This effect is seen at both the settings of the valve V2 tested. A further influence comes from the expiratory valve; additional pressure increased the $F\text{IO}_2$. This is seen in isolation in Fig. 3 which shows the influence of pressure on the gas flow and composition at constant settings of the valves V1 and V2. Gas flow is reduced with an increase in the $F\text{IO}_2$, as the expiratory valve rating is increased.

The pressure increased rapidly if the gas outlet was occluded; in five out of the six units tested the soft rubber valve was blown out of the entrainment port. Pressures of 6–10 kPa were attained transiently, before decreasing to 3–4 kPa. However, one valve remained in place with gas appearing to vent from two small holes in the body of the generator, and a sustained pressure of 40 kPa was recorded with an aneroid gauge.

Discussion

The Downs' adjustable $F\text{IO}_2$ flow generator produces a range of flows, oxygen concentrations and pressures suitable for clinical use. The flow and $F\text{IO}_2$ are dependent on the pressure within the system. Presumably, pressure increase lessens air entrainment into the venturi, which reduces overall gas flow and dilution of the driving gas. The minimum obtainable $F\text{IO}_2$ of 0.31 reflects flow resistance through one particular humidifier and this may well vary between designs. The slight dependence of $F\text{IO}_2$ upon the overall flow implies that this requires checking after any alteration to the flow or expiratory valves, if continuous oxygen monitoring is not available.

The least additional work will be required of the patient if there is no inspiratory pressure decrease within a CPAP system, therefore continuous flow designs must be capable of exceeding the patient's peak inspiratory flow (PIF). What is the PIF in pathological conditions? Pilbeam[3] suggests a figure of three to four times the minute volume, whereas Katz and Marks,[4] who studied 16 patients recovering from respiratory failure, found values very close to 37 litres/minute. Viale *et al.*[5] report similar results from 12 patients being weaned from mechanical ventilation. The consequences of the present study show that the Downs' adjustable $F\text{IO}_2$ flow generator can produce flows of at least 100 litres/minute, which should satisfy most patients' requirements.

The influence of the expiratory valve must be considered. A true threshold resistor would maintain a constant pressure independent of the flow rate of gas through it. Flow through the valve will vary considerably throughout the respiratory cycle, from a minimum of fresh gas flow minus the PIF to a maximum of fresh gas plus peak expiratory flow. Less-than-ideal valves are associated with increases of P_{aw} during expiration and decreases during inspiration and require greater efforts from the patient. Water column valves are least flow dependent,[1] but the Medic Aid valves can be placed nearer the patient and operate well at any angle.

The potential of the Downs' flow generator to develop high airway pressures is disconcerting, given that the piped oxygen supply is at 400 kPa. This feature was examined previously by Jenkins and Van-Besouw,[6] who were satisfied with the generator's safety without an additional relief valve, but they failed to record whether or not the inlet port valve was ejected during their experiment. The provision of an additional positive pressure relief valve would seem to be mandatory; a CPAP valve of a higher rating would suffice. Similarly, placing an auxiliary inlet valve near the patient connector is required for complete safety. Some airway pressure alarms[7] will function in a CPAP mode while displaying P_{aw} and the use of one should be considered. A display of P_{aw} permits the correct flows to be used for each patient as the P_{aw} inspiratory decrease is abolished as the flow exceeds the PIF. Finally, a visual inspection of the expiratory valve should confirm that the gas flow is continuous throughout the respiratory cycle.

The generator's disadvantages include high gas consumption and the greater volume of gas to be warmed and humidified; noise from the entrainment of room air can be reduced by fitting a bacterial filter over the inlet port.

The Downs' flow generator appears to meet almost all the requirements[8] of the International Standards Organisation standard 5358–1980 except that the potential to remove the Schraeder probe means that the gas connector is not gas specific. The only standard[9] which stipulates gas flows for continuous flow devices requires that Entonox machines be capable of delivering 300 litres/minute during peak inspiration. This figure should be compared with those quoted above for intensive care patients. The Downs' flow generator can provide the full range of flow pressures and oxygen concentrations required of a CPAP system for adult and paediatric use. Intermittent oxygen concentration monitoring is required, but continuous pressure monitoring is recommended. Additional valves for positive pressure relief and air inlet are necessary for complete safety. Such a system, used with an appropriate expiratory valve, should offer the benefits of CPAP with the minimum additional respiratory work.

Appendix

The gas flows reported in this paper have been corrected for the effects of changing gas composition on the pneumotachograph. Values for the viscosity of a mixture of nitrogen and oxygen were interpolated from those of the pure gases (N_2 174 micropoise, O_2 201 micropoise at 20°C) and ignoring any departure from linearity resulting from $O_2 - N_2$ interaction. The graph of $F\mathrm{IO}_2$ against correction factor is a line from zero at an $F\mathrm{IO}_2$ of 0.2 and -11% at 1.0.

Acknowledgments

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References

1. Cox D, Niblett DJ. Studies on continuous positive airway pressure breathing systems. *British Journal of Anaesthesia*, 1984; **56:** 905–10.
2. Fried JL, Downs JB, Davis JEP, Heenan TJ. A new venturi device for administering continuous positive airways pressure. *Respiratory Care* 1981; **26:** 133–6.
3. Pilbeam S. *Mechanical ventilation. Physiological and clinical applications*. USA: Multi-Media Publishing, St. Louis: 1986.
4. Katz JA, Marks JD. Inspiratory work with and without continuous positive airways pressure in patients with acute respiratory failure. *Anesthesiology* 1985; **63:** 598–607.
5. Viale JP, Annat G, Bertrand O, Godard J, Motin J. Additional inspiratory work in intubated patients breathing with continuous positive airway pressure systems. *Anesthesiology* 1985; **63:** 536–9.
6. Jenkins JG, Van-Besouw JP. Safety of a new system for continuous positive pressure. *Anaesthesia* 1986; **41:** 1155.
7. Airway pressure monitors. *Hospital Equipment Information* 1987; **169**.
8. Continuous flow inhalational apparatus (anaesthetic machines) for use with humans. *International Standard (ISO)* 5358–1980.
9. Specification for anaesthesia and analgesia machines. Part 2 Premixed Nitrous Oxide and Oxygen from a single container. *British Standard* B.S.4272: 1968.

Anaesthesia, 1988, Volume 43, pages 770–772

APPARATUS

Patient-controlled analgesia—the need for caution

A case report and review of adverse incidents

D. W. THOMAS AND H. OWEN

Summary

Respiratory depression and oversedation occurred during the administration of patient-controlled analgesia because of a broken syringe barrel. Possible complications in the use of patient-controlled analgesia are reviewed. These may be because of prescription or provision errors, patient factors or equipment problems.

Key words

Postoperative analgesia; patient controlled analgesia.
Complications; respiratory depression.

The principle of patient-controlled analgesia (PCA) has been accepted widely as an effective and safe method of pain relief. A variety of commercial PCA systems has become available in response to the interest shown in this method of opioid delivery.

The first patient-controlled intravenous analgesia device had no control over the rate of drug administration; the only limit on dose was the amount of drug held in the reservoir.[1] The early electromechanical PCA machines enabled the size of self administered bolus (demand) and the permitted maximum frequency of demand (lock-out interval) to be prescribed, but there were no failsafe provisions, and close supervision was necessary.[2–4] Several safety features were built into the pioneering Cardiff Palliator.[5] In addition to demand dose and lockout interval, the maximum dose to be administered could be entered and, in order to prevent 'accidental' dosage, the system required two presses of the handset button to activate drug delivery. The primary safety feature was still the quantity of drug held in the syringe, which the authors emphasised should not exceed a dose which the patient could survive if given as an accidental bolus.

The On-Demand-Analgesic-Computer (ODAC) was the first PCA device with a high level fail-safe reliability, and was developed from the prototype Newcastle system.[6] The ODAC had all the features of the other systems but also had sensors to detect air or blockage in the drug delivery system and unauthorised entry to the syringe compartment. In addition, it had a suite of diagnostic routines to identify electronic or mechanical malfunction within the device.

Three PCA devices designed for use after surgery are marketed currently in Europe, USA and Australasia.† All are sophisticated, but none is completely 'failsafe' and an incident which led to profound respiratory depression in a patient using PCA is reported here.

Case report

A fit, young adult male was scheduled for an upper abdominal operation. At the pre-anaesthetic visit, he was offered the use of a patient-controlled analgesia system in view of the pain expected from his surgery. The principles of PCA were explained to him and he was familiarised with the equipment.

Surgery was protracted but uneventful; he received a total of 20 mg of intravenous morphine sulphate during the procedure and a further 10 mg morphine sulphate intravenously in the recovery room, during the 10 minutes before PCA was started. He returned to the ward and continued to obtain satisfactory analgesia for the next 24 hours using PCA with morphine sulphate delivered intravenously by a Lifecare PCA Infuser. The drug cartridge contained 150 mg morphine sulphate and the machine was set to administer 2 mg at each demand. This concentration was considered to be safe in view of the proven accuracy of the infuser during laboratory testing at our hospital. It was decided after 24 hours to continue PCA for a second day. However, the demand dose was reduced from 2 mg to 1 mg because of a slow respiratory rate and sedation. The

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† Harvard PCA–Bard Medisystems Division; Lifecare PCA Infuser–Abbott Laboratories; Graseby PCAS–Graseby Medical.

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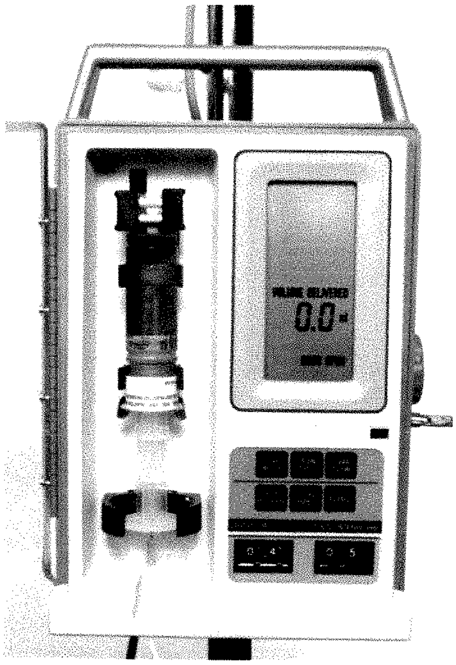

Fig. 1. An early model of the Abbott Lifecare PCA Infuser, open to demonstrate configuration of the disposable drug cartridge.

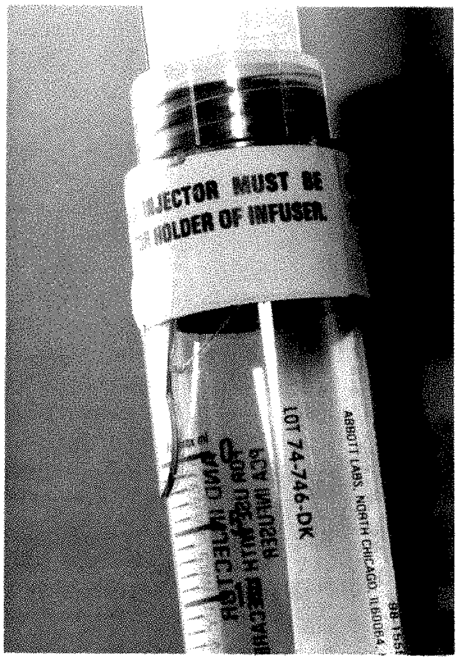

Fig. 2. The disposable drug cartridge, which shows the crack in the glass barrel of the syringe, held in place by the manufacturers' warning label.

infuser cartridge which contained morphine (Fig. 1) was replaced at this time.

Thirty minutes later, the ward staff noticed that the patient was unconscious with a ventilatory rate of 4/minute. The medical staff were called, and 0.15 mg naloxone was administered intravenously, which resulted in antagonism of the sedation and low respiratory rate. Close examination of the PCA device revealed an empty syringe and a pool of fluid on the floor. A large crack was noted in the side of the syringe (Fig. 2) and it was assumed that morphine sulphate solution had leaked on to the floor. The PCA device was disconnected and the patient was transferred to a high dependency unit where he required a total of 0.25 mg naloxone over the next 12 hours. Subsequently, he made an uneventful recovery.

Equipment examination

There was a large inverted V-shaped crack in the barrel of the syringe cartridge, and the fragment of broken glass was held in place by a paper tape label affixed by the manufacturers (Fig. 2). The pump was positioned 30 cm above the patient. Tests were performed under laboratory conditions to investigate the possibility that this fault caused delivery of excess drug to the patient.

The syringe was filled with saline which contained methylene blue and the extension tubing was primed as far as the one-way valve in the delivery system. An intravenous line was connected to the other port of the Y-connector to simulate the clinical situation. The same volume of intravenous fluid as the patient had received in the 30 minutes before his collapse (50 ml), was run through the giving set. The effluent from the 'venous' end of the drip set was collected in a glass container, and the volume of fluid and degree of contamination by methylene blue were noted. The PCA machine was placed either level with, or 30 cm above, the outlet of the giving set. The time for the syringe to empty completely, the volume in the glass container and the degree of contamination with blue dye were recorded.

The volume delivered into the glass was 50 ml, and there was no contamination with dye when the outlet of the giving set was at the same height as the syringe in the PCA machine. All the contents of the syringe leaked on to the floor through the crack. Air entered the syringe when the outlet was placed 30 cm below the syringe, and there was considerable blue colouring of the fluid which drained into the glass container. The volume measured in the container was 80 ml; approximately 5 ml of blue-stained saline had leaked out of the system on to the floor.

Discussion

Respiratory depression in this patient was caused by the overadministration of morphine sulphate because of a combination of factors. The first was the positioning of the PCA machine higher than the level of the patient. It is possible that the second fault would not have led to a potentially serious outcome if this had not been done. However, under a gravitational effect, the broken syringe emptied its contents into the patient in a manner similar to a manometer. The paper tape safety warning label held the glass fragment in place and allowed air to leak into the system while retaining most of the drug solution (Fig. 2).

There have been several isolated reports of respiratory depression during PCA. Adverse incidents with PCA can be caused by errors in prescription or programming, patient factors or equipment problems.

Most opioid analgesics have been used in PCA and can provide good pain relief after surgery.[7] In Keeri-Szanto's cybernetic model of PCA, patients demand analgesia until acceptable pain relief is achieved.[8] This is an oversimplification, for if the demand dose chosen is too small, the incidence of therapeutic failure becomes high.[9] PCA cannot be effective if the lockout interval is too long for the drug being used or for the particular demand dose. Conversely, nausea or excessive sedation may result if the demand dose is too large, and the potential for drug accumulation exists if the lockout interval is too short.[10] The device may simply be misprogrammed to deliver an excess; PCA devices in which the dose is entered in mg rather than ml minimise errors in calculation.

Many errors can occur in the preparation of PCA. In one report a patient received pethidine 100 mg instead of the prescribed 10 mg.[11] The wrong concentration of drug may be prepared (the process of dilution should be checked by a second physician or nurse), or the one-way valve, which should be used when PCA is 'piggy-backed' on an intravenous infusion,[12] may be omitted or faulty.[11] Care must be taken when the syringe or cartridge is refitted or changed to avoid administering a bolus inadvertently. The tubing connecting the syringe (or cartridge) to the intravenous catheter should be clamped to avoid repetition of an incident in which a 40–50 μg bolus of sufentanil was administered accidentally.[11]

PCA requires the cooperation and understanding of the patient. Some patients are unsuitable for PCA and others may not wish to use it, or use it inappropriately.[8] Patients who are addicted to opioids appear to be unsuitable for PCA; two addicted patients have been described '. . . who self administered narcotics to the brink of unconsciousness, "coming up for air" only long enough to trigger administration of some more drug.'[8] Ventilatory depression during PCA may also arise from postoperative haemorrhage. The originally prescribed demand dose may become a relative overdose because of the contracted vascular volume and preferential cerebral perfusion associated with hypovolaemia.[13]

The drug delivery system must be intact for PCA to be effective. A blocked intravenous catheter or kinked, leaking or disconnected tubing results in ineffective analgesia.[14] The cracked cartridge described above resulted in an accidental overdose by allowing drug to drain into the circulation by gravity. (A modification to the drug delivery system, of which we were unaware, had been made by the manufacturers to prevent this problem occurring).

The participants of the first international workshop on PCA accepted that all demands by the patient should consist of two button presses within a short time before the apparatus was activated.[15] However, all the devices under discussion require only a single button press. The Lifecare PCA infuser and the Harvard PCA use the same handset; this has a proud button which has been observed to initiate a demand when dropped on the floor from a bed.[14] (The latest models of both have a clip to keep the handset on the bed). The Graseby PCAS has a pneumatic push button which could be 'locked on'.[16] (The manufacturers have since modified the product).

An article in 1971 which described one of the earliest apparatus for PCA contained a list of 'fail-safe' devices.[3] It stated that the circuitry should not be affected by the patient 'freezing' on the button and that 'no gravity or syphoning off' should be involved. The second feature was to improve accuracy of drug delivery, but in retrospect it could have alerted us to the potential problem encountered in the case described above.

This case report highlights the importance of abiding by established PCA guidelines, and of thorough checking of equipment. The introduction of more sophisticated and expensive PCA machines does not rule out the possibility of simple faults that may be potentially lethal. The technique of PCA is inherently safer than continuous mandatory infusion but is not without hazard. It is likely that it will be used more widely in the future,[17] but there is still need for caution.

Acknowledgments

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References

1. Scott JS. Obstetric analgesia. A consideration of labor pain and a patient-controlled technique for its relief with meperidine. *American Journal of Obstetrics and Gynecology* 1970; **106:** 959–78.
2. Forrest WH, Smethurst PWR, Kienitz ME. Self-administration of intravenous analgesics. *Anesthesiology* 1970; **33:** 363–5.
3. Keeri-Szanto M. Apparatus for demand analgesia. *Canadian Anaesthetists' Society Journal* 1971; **18:** 581–2.
4. Sechzer PH. Studies in pain with the analgesic-demand system. *Anesthesia and Analgesia* 1971; **50:** 1–10.
5. Evans JM, McCarthy J, Rosen M, Hogg MIJ. Apparatus for patient-controlled administration of intravenous narcotics during labour. *Lancet* 1976; **1:** 17–8.
6. Hull CJ, Sibbald A. Control of postoperative pain by interactive demand analgesia. *British Journal of Anaesthesia* 1981; **53:** 385–91.
7. Lehmann KA. Autoregulation de l'analgésie postopératoire. *Cahiers d'anesthesiologie* 1985; **33:** 119–23. Autoregulation of postoperative analgesia. (English title).
8. Keeri-Szanto M. Drugs or drums: what relieves postoperative pain? *Pain* 1979; **6:** 217–30.
9. Lehmann KA, Brand-Stavroulaki A, Dvorzak K. The influence of demand and loading dose on the efficacy of postoperative patient-controlled analgesia with tramadol. *Schmerz Pain Douleur* 1986; **7:** 146–52.
10. Owen H, Mather LE, Runciman WB, Carapetis RJ, Upton RN. The lockout interval in patient controlled analgesia: A rational basis for choice? *British Journal of Anaesthesia* 1987; **59:** 1328–9.
11. White PF. Mishaps with patient-controlled analgesia. *Anesthesiology* 1987; **66:** 81–3.
12. Rosen M, Williams B. The valved-y-Cardiff connector (VYC con). *Anaesthesia* 1979; **34:** 882–4.
13. Tamsen A, Hartwig P, Fagerlund C, Dahlstrom B, Bondesson U. Patient-controlled analgesia therapy: clinical experience. *Acta Anaesthesiologica Scandinavica* (Suppl. 74) 1982; 157–60.
14. Owen H, Glavin RJ, Reekie RM, Trew AS. Patient-controlled analgesia. Experience of two new machines. *Anaesthesia* 1986; **41:** 1230–5.
15. Lassener J, Norman J. Future work on patient-controlled analgesia: summary of open discussion. In: Harmer M, Rosen M, Vickers MD, eds. *Patient controlled analgesia.* Oxford: Blackwell Scientific Publications, 1985; 191–4.
16. Hanning CD, Ogden B, Parry P. Graseby PCAS pumps—a potential hazard. *Anaesthesia* 1987; **42:** 559–60.
17. Rosen M. Patient-controlled analgesia. *British Medical Journal* 1984; **289:** 640–1.

Anaesthesia, 1988, Volume 43, pages 773–775

HISTORICAL

The development of the anaesthetic vaporizer

The contribution of A.G. Levy

D. ZUCK

Summary

The innovatory features incorporated into A.G. Levy's regulating chloroform inhaler, and their contribution to modern vaporizer design, are examined. Levy may be credited with the important realisation that the gas mixture which leaves the vaporizing chamber is fully saturated at all flow rates; with the concept of the splitting ratio; with appreciation of the importance of the application of Reynolds' researches on laminar and turbulent flow to the design of anaesthetic apparatus; and with the provision of a facility to compensate for changes of temperature in the vaporizing chamber.

Key words

History; vaporizers.

A.G. Levy demonstrated, in 1904 at a meeting of the Royal Medical and Chirurgical Society, an 'Apparatus designed for Regulating the Strength of Chloroform Vapour Administered in the Atmosphere Inhaled and at the same time to restrict its maximum strength . . . The instrument indicated with an approximate degree of accuracy the percentage of chloroform vapour inhaled.'[1] This apparatus was a drawover vaporizer. 'The main principle involved was the suction of air over a surface of chloroform by the respiration and the dilution of the mixture of air and chloroform vapour thus obtained by such a further proportion of air as may be desired before it reached the respiratory passages.'

The vaporizing chamber was annular in shape; the inlet and outlet tubes were separated by a vertical radial diaphragm. This chamber rested in a larger vessel which contained 1 litre of water at 20°C; since, as Levy explained, water has a higher specific heat than chloroform, this water jacket served to maintain the temperature of the chloroform. The device that determined the strength of vapour that reached the patient consisted of a regulator and a compensator. The regulator 'consisted of two concentric cylinders . . . the inner of which could be made to revolve within the outer by moving a lever. The cylinders contained reciprocally acting apertures, one leading from the chloroform chamber and the other communicating directly with the air. When either was partly open the other was shut in the same proportion. Thus the chloroform might be diluted to any desired extent. The lever before mentioned carried an index hand which travelled over a scale indicating the percentage of vapour. This scale was plotted by means of a series of experimental estimations.' The compensator was 'a circumferential air-slot, which might be covered up to any desired extent by a revolving collar.' The apparatus could produce a maximum concentration of 3.5%.

This design was fairly conventional. The earliest chloroform inhalers, such as Snow's, had been drawover in type.[2] The entire proportion of the inhalation that passed through the vaporizer was unregulated, and the resultant mixture was diluted by the admission of more air through a valve or rotating collar near the facemask. Levy was well acquainted with Snow's writings, and cited him frequently. The proportion of inspired air that passed through the vaporizer could be varied in this apparatus. The same applied both to the recently introduced portable model of the Harcourt inhaler,[3] and to the lesser-known experimental table model.[4] In this latter, in order to restrict the final vapour concentration to a maximum of 2%, the liquid chloroform was diluted with alcohol to a 20% solution, and the alcohol was removed subsequently from the vapour mixture by passage through a water-bath. A series of baffles in the vaporizing chamber created an air channel 4.57 m long to ensure saturation of the mixture. The output could then be diluted with air.

The idea of a facility to vary the air flow through the vaporizing chamber may have been an innovation; but the concentration of the regulated mixture produced by Levy's apparatus varied substantially depending on the tidal volume, and could be further diluted, if indicated, by means of the compensator,[5] so it is difficult from the description to see how all this could have done other than to affect the accuracy of the calibration.

The problem with such inhalers was subsequently demonstrated by Levy himself. His critique of the much-vaunted Harcourt inhaler is reproduced in his monograph.[6] It must be said, however, in fairness to Harcourt, that the

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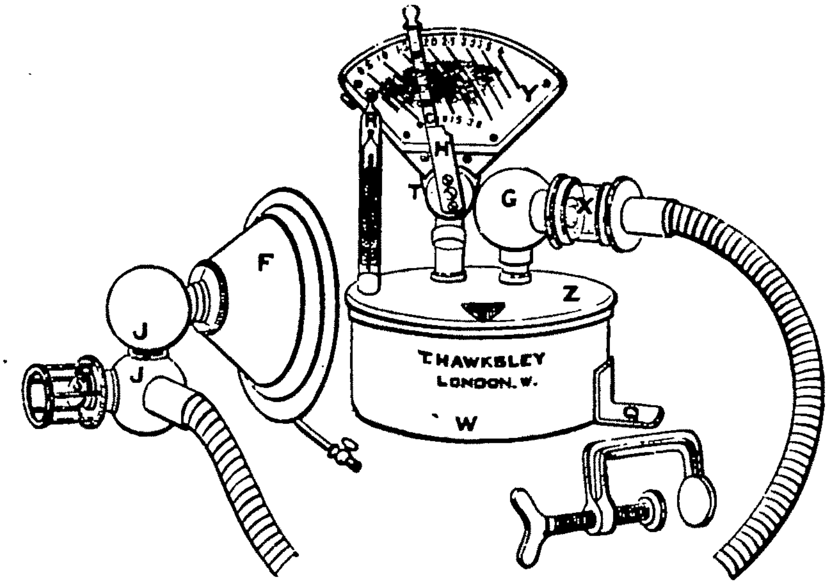

Fig. 1. Levy's regulating chloroform inhaler.[6] F, facepiece; JJ, double junction between facepiece and tube; S, expiratory valve; X, glass chamber containing inspiratory valve; G, mixing chamber with air aperture (not shown); Z, cover containing chloroform chamber; W, water bath. R, thermometer; T, tap regulating chloroform supply (inlet not shown); H, index hand. Y, percentage scale.

portable version was not his first choice, but was produced at the request of the clinical users. The faults of Levy's own apparatus can be discerned from his subsequent publication, and were later set out by Hewitt.[7] The concentration of chloroform varied considerably with the respiratory effort, or tidal volume, of the patient; and there were 'the disadvantages of making the respiratory pump of the patient also the pump of an apparatus.' In Levy's apparatus the strength of the patient's inhalations, i.e. the tidal volume, was indicated by the swing of a hinged mica valve set in a glass inlet chamber; in use, this had to be watched since, if breathing was too deep, the 'compensator' had to be brought into use to reduce the concentration of chloroform.

Levy described the second, 'simplified and improved', version of his vaporizer in the following year: the definitive and well-known 'Regulating Chloroform Inhaler.'[8] There were three principal and very significant differences between this and the original apparatus. The first was that the temperature of the water jacket was much higher, initially 40°C. The second was that the size of the main air inlet remained constant; any change in chloroform percentage was achieved only by a change in the inflow to the chloroform chamber. The third was the provision of a means of compensating for changes of temperature in the vaporizing chamber. Levy explained, 'An essential principle of the apparatus is the apparently anomalous one of heating up the chloroform to yield a strong vapour, which is subsequently weakened by dilution with pure air, and it is now necessary to explain this procedure. The condition imposed of propelling an air current over an evaporating surface by the suction power of human inspiration is far from an ideal one, for the air current takes up a greater or less proportion of vapour according as its passage is slow or rapid, or, in other words, according as a weak or strong draught is induced in accordance with the variable action of the human respiratory pump.'

He described an experiment whereby conditions similar to those of human ventilation were reproduced by means of a suction bellows of variable capacity worked by a wheel and a crank. Suction over the surface of the chloroform, with the main air inlet of the inhaler occluded, resulted in a vapour concentration whose strength varied inversely with the tidal volume. 'The water bath was filled at 20°C and the capacity of the bellows was set at 550 cubic centimetres. By turning the bellows wheel a strong intermittent draught was produced and the percentage of vapour taken up was 3.6. When, however, the capacity of the bellows was reduced to 160 cubic centimetres the percentage of vapour rose to 6.2. It is seen, therefore, that direct suction over a chloroform surface is contra-indicated. However, by drawing a large proportion of the draught through the air aperture, the current through the chloroform chamber is only a fraction of the whole, and is therefore in all cases a relatively slow current. Now the percentage of vapour taken up by sluggish currents does not increase, as these currents become slower, in the same proportion as the percentage increases in the case of quicker-moving currents.' (Here Levy reproduced a chart, derived experimentally by use of his variable capacity suction bellows, which showed that the change in vapour concentration decreased in something approaching an exponential manner as the flow through the vaporizer was reduced.) 'The indication, therefore, is to allow only slow currents, which take up a large percentage of vapour, to pass over the chloroform and to dilute them with pure air down to respirable mixtures.' Levy demonstrated that this in itself will reduce substantially the effect on the final percentage of variations in the tidal volume. But there was another factor of some importance. Levy, in the design of the second version of his inhaler, elaborated on a feature that he had mentioned briefly in the description of his first. He had become acquainted with the work of Osborne Reynolds on the flow of fluids through tubes,[9] and brought this into practical effect. '... advantage is taken of another natural law to bring the readings into closer approximation. This is the law of viscous flow of fluids. It will be observed that while the pure air enters through a simple thin-walled aperture, the chloroform current flows through a series of tubes and passages, which introduce a measure of resistance to its flow. Now this resistance is of such a nature that it acts relatively more powerfully on slower-moving currents, and thus in the case of weak suction the disproportion between the air current and the chloroform current becomes greater than in the case of strong suction.' (In a footnote Levy explained that 'This is an application of the law that flow through an aperture is approximately proportional to the square root of the driving pressure, whereas viscous flow, as flow through tubes, is directly proportional to the pressure.') 'In this way is induced a greater dilution at low suction pressures than at the higher suction pressures.' Additionally, of course, the higher the saturated vapour pressure in the chamber, the smaller the flow of air needed, which again contributes to the constancy of output. The final effect was that with the index pointer set at 2% and the water bath temperature at 40°C the actual percentage of chloroform delivered between tidal volumes of 160–550 ml varied within 0.1 %.

Levy later described it, 'The principle of this type of inhaler is the splitting of the air current, so that part passes over the anaesthetic and takes up vapour, and part does not . . .'.[10] Thus all the complications of multiple air inlets and dilutions, in his own apparatus and others, of regulators and compensators, were set aside. Levy had arrived at the modern concepts of the 'splitting ratio' and the prerequisite that all the gas mixture which leaves the vaporizing chamber is fully saturated at all flow rates. This principle has been succinctly expressed by Parbrook.[11]

The percentage scale, as regards temperature compensation, was set out as a series of isobars. The index pointer was marked off in °C (Fig. 1). The temperature in the vaporizing chamber was indicated by an indwelling thermometer. The appropriate temperature graduation on the pointer was set against the required percentage isobar to achieve compensation for alterations. This varied the flow through the vaporizing chamber. Levy was very much aware of the need for low resistance breathing passages in drawover apparatus, and the parameters he suggested accord closely with present British Standards for connectors in anaesthetic systems.

The significance of Levy's work seems to have been recognised first by the physiologist N.H. Alcock, who based the design of his calibrated, temperature compensated, plenum vaporizer on it.[12] (A study of this vaporizer is in preparation.) Alcock wrote, 'A.G. Levy points out . . . that the percentage of chloroform will be independent of the air current when in any machine the stream of air is divided, so that part passes over the liquid chloroform and part direct to the patient, the perfection of adjustment depending on the relative velocity of the two paths and the amount in which viscosity comes into play in the chloroform airway. In his apparatus, which is of the "vacuum" type, the percentage was constant between the limits of 33 litres and 9 litres air stream per minute.'

Levy is now remembered mainly for his work on ventricular fibrillation in relation to light chloroform anaesthesia.[13] He made other, equally important, and more long-lasting contributions, but since these are not fully set out in his monograph, *Chloroform anaesthesia*, they have become overlooked. His contributions to vaporizer design are apparent only in his earlier publications. One is forced to the realisation from a study of his writings that he was the first of the modern scientific research anaesthetists, working with ideas, concepts and methods some 40 years ahead of most of his contemporaries.

Acknowledgments

I am grateful to Mrs M. Butler, Librarian, and Mr Martin Moor, Medical Photographer, Chase Postgraduate Medical Centre; and to my secretary, Miss E. Massen.

References

1. Levy AG. Discussion on chloroform anaesthesia (Report of Royal Medical and Chirurgical Society). *Lancet* 1904; **2:** 1496–9.
2. Snow J. *On chloroform and other anaesthetics.* London: Churchill, 1858; 81–4.
3. Harcourt V. Special chloroform committee. *British Medical Journal* 1903; **2** (Suppl.): 142.
4. Harcourt V. On two methods for the limitation and regulation of chloroform when administered as an anaesthetic. *Proceedings of the Royal Society* 1902; **70:** 504–10.
5. Levy AG. An apparatus for administering chloroform vapour mixed with air in ascertainable proportions. *British Medical Journal* 1904; **2:** 1462.
6. Levy AG. *Chloroform anaesthesia.* London: Bale, Son and Danielsson, 1922: 121–2.
7. Hewitt FW. *Anaesthetics and their administration,* 4th edn. London: Macmillan, 1912: 392.
8. Levy AG. A regulating chloroform inhaler. *Lancet* 1905; **1:** 1413–5.
9. Zuck D. Osborne Reynolds 1842–1912, and the flow of fluids through tubes. *British Journal of Anaesthesia* 1971; **43:** 1175–82.
10. Levy AG. *Chloroform anaesthesia.* London: Bale, Son, and Danielsson, 1922: 120.
11. Parbrook GD, Davis PD, Parbrook EO. *Basic physics and measurement in anaesthesia,* 1st edn. London: Heinemann, 1982: 136.
12. Alcock NH. Anaesthesia in the human subject with known percentages of chloroform vapour. *British Medical Journal* 1909; **1:** 325–9.
13. Hovell BC, Masson AHB, Wilson J. Alfred Goodman Levy (1866–1954): a biography. *British Journal of Anaesthesia* 1972; **44:** 115–21.

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HISTORICAL

The first use of physostigmine in the treatment of atropine poisoning

A translation of Kleinwachter's paper entitled 'Observations on the effect of Calabar bean extract as an antidote to atropine poisoning'

R. W. D. NICKALLS AND E. A. NICKALLS

Summary

This paper describes a clinical experiment performed by Drs Kleinwachter and Niemetschek in Prague in 1864, which showed for the first time that oral Calabar bean extract (which contains physostigmine) reverses the toxic effects of atropine. Kleinwachter's original paper is translated from the German.

Key words

History.
Parasympathetic nervous system; atropine physostigmine.

This paper relates the earliest known account of the use of physostigmine (as an extract of Calabar bean) in the treatment of systemic atropine poisoning, in Prague in 1864.[1] It was a bold therapeutic step at the time, in view of the fact that the side effects of too large a dose were known to produce muscular weakness[2] and even paralysis and death.[3]

It is significant that the two doctors involved (Dr Kleinwachter and Dr Niemetschek) were ophthalmologists,[4] in view of various reports the previous year (1863) that the conjunctival application of an extract of Calabar bean counteracts the mydriatic action of atropine.[3,5–7]

Background

The surgeon and botanist William Freeman Daniell (1817–1865) witnessed while resident in Calabar, West Africa, the use of certain poisonous seeds by the natives for the purposes of Trial by Ordeal, a common practice in that part of Africa. Daniell relates the following in a lecture to the Ethnological Society in 1846.

> 'If found guilty, they are usually forced to swallow a deadly potion, made from the poisonous seeds of an aquatic leguminous plant, which rapidly destroys life ... If, however ... the accused should be so fortunate as to throw the poison from off the stomach, he is considered as innocent, and allowed to depart unmolested.'[8]

A few years later a Scottish missionary by the name of Rev Zerub Baillie was also resident in Calabar. Baillie had previously studied medicine in Edinburgh, and in a letter to his former teacher J.H. Balfour (Professor of Medicine and Botany, University of Edinburgh), he gives the following classic description of physostigmine poisoning.[9]

> 'I have several times been called upon to visit people under the influence of this poison. The symptoms, so far as I have observed them, are as follows: The patient, when fairly under the influence, presents a peculiarly stupid, drunken look, the face is flushed and swollen, the eyes protruding, the mouth externally has somewhat the appearance of a person under salivation. At first there is a considerable flow of saliva, which eventually becomes frothy; the pulse is moderately full; the limbs gradually become powerless; the person walks very like an individual under the influence of strong drink; the muscles of the tongue, as well as the other muscles of the body, soon appear to get into a state of paralysis; the breathing becomes laborious, and the patient gradually sinks.'

Baillie subsequently sent some of these so-called Calabar beans to Professor Christison (Professor of Materia Medica and Therapeutics, University of Edinburgh) for investigation. In 1855 Christison writes,[2]

> 'Meanwhile I have fallen in with another African ordeal-poison, of much greater energy and interest ... The only notice of any kind that I have seen of it, is a short allusion to it by Dr Daniell, in an ethnological paper ... From such trials as I have made, it seems one of the most singular and intense poisons yet known, and well worthy of a more complete investigation than I have been hitherto able to accomplish.'

Christison ate, by way of experiment, one quarter of a bean and became dangerously weak.[2] Significantly, this experi-

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ment made him realise that the weakness was because of a peripheral rather than a central effect. Christison describes this realisation.[2]

> '. . . I tried to raise myself on my elbow to vomit, but failed. I made a second more vigorous effort, but scarcely moved. At once it struck me – this is not debility, but volition is inoperative.'

Somewhat later, Dr Richard Fraser (a student of Professor Christison), made an extensive study in animals of an extract of Calabar bean,[3] and discovered its miotic action on the pupil. The ophthalmologist, Dr Argyll Robertson, also worked in Edinburgh at that time. He had been investigating a variety of vegetable extracts in order to find a substance with 'actions exactly opposite to those well known to result from belladonna or atropine.' Argyll Robertson goes on to say,[5]

> 'These investigations were, however, productive of no satisfactory results, until my friend Dr Fraser informed me that he had seen contraction of the pupil result from the local application of an extract of the ordeal bean of Calabar. I resolved to investigate the action of this substance . . . to ascertain whether it exerted any influence on the accommodation of the eye.'

This work led Argyll Robertson to describe the first clinical uses of physostigmine,[5] namely to reverse the prolonged and unpleasant mydriatic action of atropine, and to constrict the pupil in cases of retinitis with photophobia, as well as ciliary muscle paralysis.

Argyll Robertson's paper which described the first clinical use of this new agent was published in March 1863,[5] and only 18 months later an extract of Calabar bean was used systemically by Drs Kleinwachter and Niemetschek in Prague to treat a case of atropine poisoning. A translation of their extraordinary paper is presented below. (In view of the historical nature of Kleinwachter's paper it is translated fairly literally, and follows the original German closely.)

Acknowledgments

We thank Mr D. Brocklebank (Staff Pharmacist, Freeman Hospital, Newcastle-upon-Tyne) for his help in the translation of the various latin prescriptions which appear in Kleinwachter's paper.

References

1. Kleinwachter. Beobachtung uber die Wirkung des Calabar-Extracts gegen Atropin-Vergiftung. *Berliner Klinische Wochenschrift* 1864; 369–71.
2. Christison R. On the properties of the Ordeal-Bean of Old Calabar, Western Africa. *Monthly Journal of Medicine* 1855; **20:** 193–204.
3. Fraser TR. On the characters, actions, and therapeutical uses of the Ordeal Bean of Calabar (Physostigma venenosum, Balfour). *Edinburgh Medical Journal* 1863–4; **9:** 35–56, 123–32 and 235–48.
4. Nickalls RWD. Physostigmine for anticholinergic drug poisoning. *Lancet* 1980; **2:** 589–90.
5. Argyll Robertson D. On the Calabar Bean as a new agent in ophthalmic medicine. *Edinburgh Medical Journal* 1862–3; **8:** 815–20.
6. Ogle JW. Observations on some of the effects of the application of the Calabar 'ordeal bean' to the eye. *British Medical Journal* 1863; **i:** 613–4 and 673.
7. Harley G. A brief account of the literary history, botanical characters, and their therapeutical properties of the ordeal bean of Old Calabar. *British Medical Journal* 1863; **ii:** 262–5.
8. Daniell WF. On the natives of Old Callebar, West Coast of Africa. *The Edinburgh New Philosophical Journal* 1846; **40:** 313–27.
9. Balfour JH. Description of the plant which produces the Ordeal Bean of Calabar. *Transactions of the Royal Society of Edinburgh* 1861; **22:** 305–12.

Translation

Observations on the effect of Calabar bean extract
as an antidote to atropine poisoning
by
Dr Kleinwachter
(Second ophthalmologist at the Kaiser Hospital, Prague)
(Berliner Klinische Wochenschrift, 1864; p. 369–71)

A number of single rooms in the Kaiser hospital in Prague were being given their annual thorough 'cleaning-out' by some of the inmates of the local prison on 20 August last year. However, while this was going on, some of the prisoners broke into a locked box which they had found in one of the rooms. They found inside the box three small bottles containing a clear liquid which they assumed to be alcoholic spirits. Four of the men then broke the seals and drank some of the contents.

At about 9 am the following morning, whilst making my rounds, I was called to go urgently to one of the rooms that the prisoners had been working in, since four of the men had apparently poisoned themselves by drinking something they had found. I hurried along to the room straight away and found that the prisoners had broken into a medical box. I found that three bottles, each of which contained four drachmas [14.2 ml] of an atropine solution, made up of one grain [64.8 mg] of atropine sulphate per drachma of distilled water [18.25 mg/ml] had had their seals broken. One bottle was more than half empty, another almost half empty, while the third appeared to be full.

The four men, who were aged between 24 and 30 years old, were affected to varying degrees. One of the prisoners, however, showed no signs or symptoms of atropine poisoning; he had indeed tasted the atropine solution assuming it to be spirits, but once he discovered his mistake he immediately spat it out. One of the other men had been more daring, and had actually swallowed a mouthful. It was not until several minutes later, according to him, that he began to notice any ill-effects. I found nothing abnormal when I examined him, other than that he had slightly dilated pupils. His temperature and pulse were both normal, and in fact his only symptom was of an uncomfortable rawness along the roof of his mouth.

The third prisoner must have swallowed considerably more of the atropine solution, because I found him in a state akin to extreme drunkenness. He was leaning against the wall, his knees sagged. his head lolled about and he was supported by one of the other prisoners. He was laughing loudly and seemed to be in excellent spirits, although he was quite delirious and unable to speak coherently. There was a cyanosed tinge to his face; his sclera were injected, and his pupils markedly dilated. His temperature was increased to 31°R [38.7°C]; his pulse was weak, but was somewhat slower than one would have expected under the circumstances, scarcely 70 beats per minute. He also continuously moved his arms and legs in a curious way, which has been described previously by Falck in association with atropine poisoning ('Important clinical signs of poisoning', by Dr C.Ph. Falck of Marburg, in *Virchow's Archives*). These movements were similar to a sort of swimming action; the prisoner continually groped about on the floor, alternately reaching out and then retracting his arms, as if he were trying to pick up some small object. He continually made efforts to get up as long as he was on the floor, and when he did not succeed he would drag himself on to 'all-fours' and shuffle around in a circle. He appeared not to be in any pain, and was generally affable and chatty, albeit incoherently. His respiratory rate was increased, but not significantly so.

The fourth prisoner was clearly the most affected. Unable to stand, he lay outstretched on the floor, scarcely able to move his limbs. His whole body, and especially his face, had taken on a cyanosed hue. His temperature was alarmingly high, and his breathing was laboured and noisy. His pulse, which was about 60 beats per minute, could scarcely be felt. The heart sounds were faint, and urine was passed involuntarily. His pupils, which did not react to light, were so dilated that the iris appeared only as a narrow peripheral band. Furthermore, his nose had started to bleed rather heavily. He appeared to be unconscious for most of the time, but would occasionally shout out incoherently and move his arms and legs in a convulsive manner. He threw himself about so violently that four men could hardly restrain him during one particularly severe episode. Careful observation suggested that he was, in fact, not in any pain; indeed, no sign of discomfort showed in his face.

There was complete dryness of the mouth in the last two prisoners described; no spontaneous retching; and no sign that either of them felt at all unwell. Indeed, they both protested noisily whenever one attempted to do anything to them. I immediately wrote out a prescription for some ipecacuanah, namely an infusion of one and a half drachma of ipecacuanah root sufficient to produce six ounces, with half an ounce of simple syrup [an infusion of 5.8 g of ipecacuanah root made up to 190 ml, together with 15 ml of simple syrup; literally this is '... ein Infusum Rad. Ipecac. e Drachma et semis ad unc. sex, Syrup. simpl. unc. semis ...'] and ordered some strong black coffee to be brought up from the kitchen. When the infusion of ipecacuanah arrived from the pharmacy, a measure was given to the fourth prisoner to drink while it was still warm. However, he only managed to swallow half the measure (about one tablespoonful). On trying some more he spat it all out. This was followed by signs not unlike those of hydrophobia, namely convulsions of the whole body when given something to drink, and in spite of help from the medical attendants, we had to abandon the ipecacuanah treatment. However, after about 5 minutes he vomited approximately two tablespoonfuls of liquid, the colour of which resembled that of egg-yolk. This was followed by another episode of violent delirium, which was more severe than any before.

When the black coffee arrived, I gave some to the third mentioned prisoner, who, in spite of considerable resistance and continuous chatter and laughter, eventually drank it. The fourth prisoner had swallowed hardly any of the ipecacuanah infusion, so I decided to write out another prescription for him: Tannic acid, 1 scruple, [1.3 g]; distilled water and cinnamon water, one ounce [28.4 ml] of each. (R Acid. tannici Scrup. 1; Aq. dest.; Aq. Cinnam. ana Unc. 1). Unfortunately, however, neither the third nor the fourth prisoner could be persuaded to take any of it. Meanwhile, the condition of these two prisoners continued to deteriorate; delirium alternated with stupor. It was necessary, therefore, as a matter of some urgency now, to induce vomiting; and a colleague of mine suggested that we should have some beer brought up from the kitchen and add some tartar emetic to it [tartarus emeticus; antimony potassium tartarate]. I therefore obtained six grains [389 mg] of tartar emetic from the pharmacy and put half the powder in each of two glasses, which were then filled up with beer. However, while the less severely affected prisoner drank the beer and subsequently vomited a small amount, the other prisoner could not be made to drink any.

For safety reasons, the hospital regulations prevented me from admitting inmates of a prison, and I therefore had to return the men to the prison. The third prisoner was not a problem in this respect, but the fourth prisoner, owing to his worsening delirium, had to be restrained in a straight-jacket before he could be taken back to the prison. On the way I met a colleague (Dr Niemetschek; a former assistant in the sight-testing clinic, and now a lecturer in ophthalmic optics), and invited him to come and see these two interesting cases. We handed the men over to the care of the prison Medical Officer when we arrived at the prison, and explained what had happened. Meanwhile, the third and fourth prisoners were put into bed with cold compresses applied to their heads. Dr Niemetschek thought that while we were discussing these two cases it might be a suitable occasion to experiment with the Calabar bean extract, and to try it orally [instead of topically on the conjunctiva], in view of its property of reversing the [mydriatic] action of atropine.

I did have a solution of Calabar bean extract, as chance would have it, which I had had prepared only a few days earlier by a reliable firm in Prague (the Golden Crown apothecary), so that we could experiment with it in our department. The concentration of the solution was six grains of Calabar bean extract per drachma of pure glycerine. This corresponds almost exactly to one drachma of Calabar bean [3.9 g] per drachma of glycerine [3.6 ml], as 3 drachma of bean yield 19 grains of extract. I went immediately and fetched the Calabar bean solution, and with the agreement of the prison Medical Officer, gave 10 drops on some sugar to the most severely poisoned man [since the physostigmine yield of Calabar bean is approximately 0.13% by weight, and the volume of 10 drops of glycerine BP using a standard eye dropper is approximately 0.7 ml, the dose of physostigmine was about 1 mg]. In addition, I attempted to put some drops of the solution into the conjunctival sac of the third prisoner, but did not succeed.

The fourth prisoner suddenly started to vomit about 15 minutes later, and brought up large quantities of liquid and food. His pulse now felt stronger, and had increased in rate to 75 beats per minute. His temperature decreased, and he passed a large quantity of urine. Furthermore, his delirium lessened, and he reported a raw sensation in his throat. The other prisoner, however, continued to show no improvement.

Later in the day, at about 2.30 pm, I returned to the prison to see how the two men had progressed, and found the [formerly] most affected prisoner sitting on his bed. He was now quite able to answer questions. His pulse was now both stronger and faster (80 beats per minute), and he complained of headache, and of feeling a bit disorientated. He also complained of poor vision, and indeed, his pupils were still quite dilated, although less so than before. By now he had recovered to such an extent that he was able to tell me how he had broken open the medical box and taken two mouthfuls from what he thought was a bottle of spirits. In contrast, the condition of the other prisoner remained unchanged despite the cold compress and the emetic which, admittedly, he had not taken. By the following day, the fourth prisoner (the one who had been affected most severely) had almost fully recovered. The third prisoner, however, was still showing signs of atropine poisoning, and his pupils were considerably more dilated than those of the man who had been treated with the Calabar bean extract.

These events are quite remarkable since only yesterday, when the two men were transferred from the hospital back to the prison, the condition of the fourth prisoner was so poor that I had seriously wondered whether he would even survive the journey. I do not believe that the effects described here can be attributed to chance alone, since the results followed so quickly and unmistakably for any one to fail to recognise the cause. It is of the utmost importance, therefore, for the nature of this antagonism between atropine and the Calabar bean extract to be determined objectively by careful experimentation. Meanwhile, however, such a new and experimental treatment for atropine poisoning using the extract of Calabar beans, must of course be undertaken cautiously.

Should the effectiveness of the Calabar bean treatment be proven, then the previously used methods for the treatment of Belladonna poisoning, all more or less arbitrary and unreliable, will be unnecessary. We will then have a safe and effective antidote for this common form of poisoning (at least, it is frequently seen in our hospital), based on a sound scientific hypothesis, rather than on a chance discovery.

The two prisoners I have described are now very much better. Indeed, the one treated with the Calabar bean extract has now fully recovered.

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Forum

The control of post-thoracotomy pain. A comparative evaluation of thoracic epidural fentanyl infusions and cryo-analgesia

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Summary

This is a comparative study of two methods to relieve postoperative thoracotomy pain. Continuous thoracic epidural infusion of fentanyl produced superior analgesia when compared with cryo-analgesia of the relevant thoracic nerves. Linear analogue pain scores were consistently lower in the epidural group reaching significance ($p < 0.05$) at 32 and 40 hours after operation. All 36 patients in the cryo-analgesia group required additional analgesia, while 12 out of the 32 patients in the epidural group did not. This difference was significant at $p < 0.001$. Respiratory and cardiovascular measurements were similar in both groups and the only side effect attributable to the epidural fentanyl was itching but this was not a problem.

Key words

Pain; postoperative.
Anaesthetic techniques, regional; epidural.

The relief of pain after thoractomy is important since pain significantly impairs pulmonary function and delays early ambulation.[1] The application of a cryoprobe to the intercostal nerves before chest closure produces prolonged analgesia without the side effects of systemically administered opiates.[2,3] This technique has been used in our thoracic surgical unit over the past 5 years with considerable success. The quality of early recovery has shown a marked improvement over previous regimens of regular intramuscular opiates.

However, there are disadvantages to the cryotherapy technique. Paresis of both the intercostal and abdominal muscles, in the early postoperative phase, may impair peak expiratory flow rates and reduce the coughing efficiency. Further, the possible long-term effects of this technique have not been fully elucidated.[4] A number of our patients have developed hyperaesthetic dermatomes which correspond to the intercostal nerves that had received cryotherapy at thoracotomy, sometimes months previously. (E.G.B.) This type of hyperaesthesia is qualitatively different from classical post-thoracotomy scar pain. Its incidence and severity prompted an appraisal of an alternative form of postoperative analgesia, namely continuous thoracic epidural infusion of fentanyl.

Intrathecal and epidural administration of opioid drugs has been extensively investigated since the discovery of spinal opiate receptors and shown to produce acceptable analgesia after thoracotomy.[5–7] However, the side effects may still be a problem, the most dangerous of which is delayed respiratory depression.[8] This has been associated more with hydrophilic than lipophilic drugs, but recent reports suggest that it can occur with long-acting lipophilic drugs[9] and also with epidural fentanyl, particularly when intramuscular opioids have been used as premedication.[10] It has not yet been reported when fentanyl alone is used for analgesia. Indeed, continuous thoracic epidural fentanyl infusion reportedly produces high quality analgesia without the need for frequent 'top-ups', is readily available in preservative-free form,[10] does not exhibit short-term tachyphylaxis and has a low incidence of other side effects such as nausea, vomiting, and urinary retention.

This investigation studies the use of continuous epidural fentanyl, as recommended by Ahuja and Strunin,[10] as an alternative method of pain relief to direct cryotherapy of the thoracic nerves. A between-patient randomised trial of the two methods was undertaken.

Methods

Eighty-six consecutive patients who presented for thoracotomy and in whom there was no contraindication to epidural analgesia were included in the trial. Written informed consent was obtained and the study was approved by the local ethics committee. The patients were allocated randomly to receive either cryo-analgesia or continuous thoracic epidural fentanyl infusion for postoperative analgesia. The pre-operative assessment included a history and full examination. Investigations included haematological, biochemical, radiological and lung function tests.

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The patients were instructed in the use of a 10-cm linear analogue scale to evaluate their postoperative pain scores.

A standardised general anaesthetic was used. Each patient received oral lorazepam as premedication. Arterial and intravenous lines were established, an ECG and a blood pressure cuff were attached. Anaesthesia was induced with thiopentone and suxamethonium was used to facilitate intubation with a Robertshaw double lumen endobronchial tube. Anaesthesia was maintained with nitrous oxide, oxygen and enflurane and incremental intravenous fentanyl (3 μg/kg). Pancuronium provided muscle relaxation and the lungs were ventilated with a Cape Waine ventilator. The inspired oxygen concentration was increased to 0.5 before one lung was collapsed and varied thereafter according to the results of the arterial blood gas analysis.

The patients were turned into the lateral position. In those who were to receive continuous epidural fentanyl an epidural catheter was introduced through the thoracic intervertebral space which corresponded with the level of surgical incision (T_{6-9}). The loss of resistance to air technique was used for identification of the epidural space. Correct catheter placement was confirmed by the catheter advancement test,[5] and 4–6 cm left in the epidural space and attached distally to a Millipore filter. A loading dose of fentanyl 1.5 μg/kg in 10 ml of sterile saline was injected into the epidural space. A solution of preservative-free fentanyl, diluted to 12.5 μg/ml in normal saline, was prepared and given by continuous epidural infusion using a volumetric infusion pump at a rate of 0.6 μg/kg/hour.

The patients in the cryo-analgesia group had six to seven intercostal nerves frozen, approximately 45 seconds for each nerve, just proximal to the angle of the rib before chest closure. Residual neuromuscular block was reversed with atropine and neostigime in both groups. The tracheas of all patients were extubated in the lateral position when spontaneous ventilation returned. Pulse rate, arterial blood pressure, axillary temperature and respiratory rates were recorded at 15-minute intervals for one hour in the recovery room. Blood gas analysis was performed and a chest X ray taken. All patients, once stable, were transferred to the thoracic high dependency unit where hourly observations of pulse, blood pressure and respiratory rates were continued. Patients were asked to record their assessment of pain at 2, 4, and 8 hours postoperatively, on a 10-cm linear analogue scale. Their lung function was measured (FEV_1, FVC, PEFR) with a small portable electronic spirometer (Pocket Spirometer, Micro Medical Instruments). These observations were then repeated at 8-hourly intervals for the first 48 hours after operation. Each patient was interviewed by one of the authors at the end of every 24-hour period, and the incidence of side effects noted. Intramuscular papaveretum (0.3 mg/kg) was available to the cryo-analgesia group if they complained of inadequate analgesia. The need for additional analgesia in this group was assessed and given by the same nurse. The epidural group was given a bolus dose of fentanyl 1 μg/kg, and the infusion rate increased in 10% increments until adequate analgesia was achieved. Here, the need for additional analgesia was also assessed by the nurse but all the alterations in regimen were performed by the anaesthetist. The increased infusion rate was continued until the end of the study period. The number of additional 'doses' of analgesics were recorded for each group over the study period of 48 hours.

Table 1. Surgical procedure.

Operation	Epidural	Cryoanalgesia	Total
Pneumonectomy	12	16	28
Lobectomy	8	12	20
Pleurectomy (decortication)	5	3	8
Miscellaneous	7	5	12

Statistical analysis. Results were subjected to statistical analysis using Student's *t*-test and Chi-squared tests.

Results

Eighty-six patients were originally included in the study but 18 were withdrawn. In five cases this was because of failure to locate the epidural space and two patients were unsuitable for the cryo-analgesia method of pain relief. The remaining 11 were withdrawn because of insufficient data collection and postoperative complications not related to either method of pain relief. Of the remaining 68, 32 received continuous epidural fentanyl and 36 cryo-analgesia.

Table 1 shows the surgery carried out and the distribution between the two groups. The miscellaneous group included 10 cases in which the lung tumour was inoperable, one carcinoid tumour and one mediastinal cyst. The distribution of the various operations was similar in the two groups. There was also no significant difference between the two groups with respect to age, weight and all other pre-operative measurements. Tables 2 and 3 indicate the range of mean values for the postoperative cardiovascular and respiratory measurements respectively. The results

Table 2. Cardiovascular measurements. Values expressed as range of mean (SD).

Measurement	Epidural	Cryo-analgesia	Significance
Heart rate	84 (12)–95 (18)	81 (13)–94 (14)	NS
Systolic arterial pressure, mmHg	121 (19)–133 (14)	119 (14)–130 (20)	NS
Diastolic arterial pressure, mmHg	70 (10)–76 (10)	73 (9)–79 (11)	NS

Table 3. Respiratory measurements. Values expressed as range of mean (SD).

Measurement	Epidural	Cryo-analgesia	Significance
Respiratory rates, mean (SD)	21 (3)–23 (4)	21 (4)–24 (5)	NS
PFR, litres/minute, range, (SD)	80 (40)–160 (68)	105 (54)–135 (60)	NS
FEV_1, litres, range (SD)	0.65 (0.27)–1.1 (0.47)	0.69 (0.28)–0.97 (0.30)	NS
FVC, litres, mean (SD)	0.86 (0.32)–1.37 (0.59)	0.94 (0.40)–1.19 (0.31)	NS

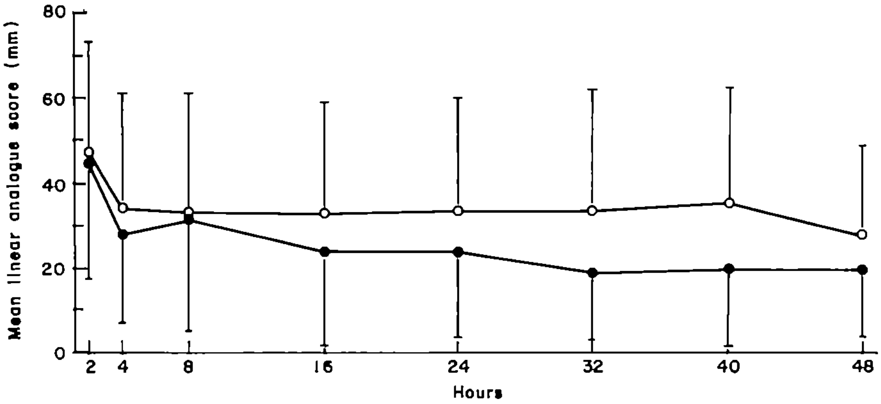

Fig. 1. Mean (SD) linear analogues at each time interval in both groups. ●—●, epidural fentanyl; ○—○, cryoanalgesia.

Table 4. Additional analgesia.

Number of additional doses	Number of patients	
	Cryo-analgesia	Epidural fentanyl
None	0	12
1	2	14
2	8	5
3	8	1
4	6	0
5	4	0
6	5	0
7	1	0
8	2	0
Totals	36	32

show that there was no significant difference between the two groups when postoperative heart rates, systolic and diastolic arterial pressures, respiratory rates and lung function tests were compared at each time interval. In addition, the lung function measurements in both groups were very poor in the initial postoperative period and, despite the steady improvement over the subsequent 48-hour period, remained well below pre-operative values.

The number of additional doses of analgesia in both groups is shown in Table 4. All 36 patients in the cryotherapy group received additional analgesia. Twelve patients out of 32 required no additional analgesia in the continuous thoracic epidural fentanyl group. The difference between both groups was significant ($p < 0.001$). The mean linear analogue scores at each time interval in both groups are illustrated in Fig. 1. The mean linear analogue scores at all time intervals were lower in the epidural group and the difference proved to be significant at 32 and 40 hours, ($p < 0.05$).

The side effects are shown in Table 5, the only significant difference in them was itching in the epidural group. The incidence of drowsiness is high in both groups but it was neither significant nor did it last for more than 24 hours.

Discussion

The relief of pain after thoracotomy has been reviewed recently by Conacher.[4] He concluded that there is no single outstanding method and the best pain relief is obtained by a mixture of two or more methods such as systemic opioids and regional blocks. He quotes evidence[11] in relation to the present study, to support the observation by Butchart about the long term effects of cryotherapy to the thoracic nerves. He also discusses the use of neuraxial opioids and rightly draws attention to the major disadvantage of respiratory depression which may occur either early or late in the postoperative period. Failure to insert a thoracic epidural cannula is quoted in another series,[12] as 1 in 10 and our failure rates confirm this finding.

The postoperative measurements of cardiovascular parameters show that there is no significant difference between the two groups. This is particularly important, since in this unit all patients are nursed postoperatively in the sitting position as soon as they have regained consciousness. Hypotension in this position is the main reason why epidural local analgesic solutions are considered unsuitable for postoperative thoracic pain relief[4] but continuous epidural fentanyl does not cause hypotension in this position, so the technique is acceptable. Comparative analysis of the respiratory variables also shows no significant differences, but both groups have considerable reductions from the values before operation and confirm other studies.[6,13]

Painful stimuli after thoracotomy are transmitted along four pathways, the vagi, phrenic, sympathetic and intercostal nerves through the spinal cord, although other routes may be present.[4] Cryotherapy is only applied to the intercostal nerves, so pain impulses still travel along the alternative pathways. Thus it is not surprising that all the cryotherapy group needed additional analgesia. Those patients who had received continuous epidural analgesia required statistically less additional analgesia than those in the cryotherapy group. They also had significantly lower pain scores at 32 and 40 hours.

The fact that the ward nurses were responsible for assessing when pain relief was required and injected the intramuscular analgesia themselves but had to call the anaesthetist to give additional epidural fentanyl may have biased the results; it may have led to an increase in the number of additional doses of analgesia in the cryotherapy group. Further, as the linear analogue scores were lower in

Table 5. Side effects.

	Epidural	Cryo-analgesia	Significance
Itching	44%	8%	$p < 0.01$
Drowsiness	78%	78%	NS
Urinary retention	6%	11%	NS
Nausea	22%	28%	NS

the epidural group, this suggests that there were no serious delays in the administration of additional doses in this group. Conversely, it could be argued that the anaesthetist was more skilled in adjusting analgesia requirements in the same group. However, this would not explain why 12 out of 32 patients in this group did not require any additional analgesia. We believe that this tends to confirm the clinical impression that continuous epidural fentanyl produces better quality and more consistent analgesia than cryotherapy. The original work[10] on continuous epidural fentanyl showed that, as well as acting at a spinal level, there was also a concomitant blood level of fentanyl which probably contributed to pain relief by central action. The results obtained by Keenan *et al.*[14] also illustrated this point when nonsteroidal anti-inflammatory drugs administered per rectum immediately after thoracotomy significantly reduced the need for postoperative intramuscular opioids in patients who had received cryotherapy during thoracic surgery. Approximately a third of the group who received continuous epidural fentanyl required no further analgesia and this probably means that there was an adequate block of most pain pathways and a sufficient blood level to obtund centrally mediated pain. In addition, satisfactory analgesia in the other two thirds could be obtained by minimal incremental doses of epidural fentanyl. It may be that an increased initial epidural infusion rate could result in more complete analgesia without significant respiratory effects.

Like all therapeutic measures there was a price to pay, albeit small, in the continuous epidural group. Itching can be controlled by drugs which do not affect respiration, but it was not a major problem in our patients and did not require treatment. Anaesthetists are sometimes worried about the injury to the spinal cord especially when a thoracic epidural is performed, but the evidence at the moment is that damage does not occur.[15,16]

In conclusion, a continuous epidural infusion of fentanyl seems to be a very useful and effective method of relieving post-thoracotomy pain. It must however be emphasized that although marked respiratory depression is not a significant feature of this technique, patients on such a regimen should be managed on a High Dependency Unit until the epidural infusion has been discontinued.

Acknowledgments

This study started as a result of the enthusiasm and dedicated work of the late Dr B. Ahuja who was a Senior Registrar at the Department of Anaesthetics, the University Hospital of Wales. We also acknowledge the tremendous help given by the staff in theatre and Ward E5 at Llandough Hospital. We are indebted to both Dr R.G. Newcombe from the Department of Medical Computing and Statistics UWCM and for a grant from the Heart Research Fund of Wales to purchase equipment. We also thank Mr I.M. Breckenridge, FRCS, Mr S.H. Armistead, FRCS, and Dr P.L. Jones, FFARCS, for their assistance and Mrs M. Johnson for her secretarial help.

References

1. Simpson BR, Parkhouse J, Marshall R, Lambrechts W. Extradural analgesia and the prevention of postoperative respiratory complications. *British Journal of Anaesthesia* 1961; **33:** 628–41.
2. Katz J, Nelson W, Forest R, Bruce DL. Cryoanalgesia for post-thoracotomy pain. *Lancet* 1980; **1:** 512–3.
3. Maiwand O, Makey AR. Cryoanalgesia for relief of pain after thoracotomy. *British Medical Journal* 1981; **282:** 1749–50.
4. Conacher ID. Pain relief following thoracic surgery. In: Gothard JWW, ed. *Baillière's clinical anaesthesiology*. London: Baillière Tindall, 1987: 233–57.
5. El-Baz NMI, Penfield Faber L, Jensik RJ. Continuous epidural infusion of morphine for treatment of pain after thoracotomy: a new technique. *Anesthesia and Analgesia* 1984; **63:** 757–64.
6. Shulman M, Sandler AN, Bradley JW, Young PS, Brebner J. Post-thoracotomy pain and pulmonary function following epidural and systemic morphine. *Anesthesiology* 1984; **61:** 569–75.
7. Cousins MJ, Mather LE. Intrathecal and epidural administration of opioids. *Anesthesiology* 1984; **61:** 276–310.
8. Bromage PR. The price of intraspinal narcotic analgesia: basic constraints. *Anesthesia and Analgesia* 1981; **60:** 461–63.
9. Wust HJ, Bromage BR. Delayed respiratory arrest after epidural hydromorphone. *Anaesthesia* 1987; **42:** 404–6.
10. Ahuja BR, Strunin L. Respiratory effects of epidural fentanyl. Changes in end-tidal CO_2 and respiratory rate following single doses and continuous infusions of epidural fentanyl. *Anaesthesia* 1985; **40:** 949–55.
11. Barnard D. The effects of extreme cold on sensory nerves. *Annals of the Royal College of Surgeons of England* 1980; **62:** 181–7.
12. James EC, Kolberg BS, Iwen GW, Gellatly TA. Epidural analgesia for post-thoracotomy patients. *Journal of Thoracic and Cardiovascular Surgery* 1981; **82:** 898–903.
13. Spence AA, Logan DA. Respiratory effects of extradural nerve block in the postoperative period. *British Journal of Anaesthesia* 1975; **47:** 281–3.
14. Keenan DJM, Cave K, Langdon L, Lea RE. Comparative trial of rectal indomethacin and cryoanalgesia for control of early post-thoracotomy pain. *British Medical Journal* 1983; **287:** 1335–7.
15. Conacher ID, Paes ML, Jacobson L, Phillips PD, Heaviside DW. Epidural analgesia following thoracic surgery. A review of two years' experience. *Anaesthesia* 1983; **38:** 546–51.
16. Hellman K. Epidural anaesthesia in obstetrics: a second look at 26 127 cases. *Canadian Anaesthetists' Society Journal* 1965; **12:** 398–404.

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Epidural fentanyl for shaking in obstetrics

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Summary

This study assesses the efficacy of epidural fentanyl in the relief of shaking associated with epidural analgesia. Fifty mothers whose shaking was sufficient to cause distress were divided randomly to receive either fentanyl 25 μg in 5 ml sterile normal saline

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or 5 ml of saline through their in-situ epidural. Shaking stopped within 15 minutes in 18 out of 25 (72%) of those given fentanyl but in only 4 out of 25 (16%) of the saline group and this is statistically significant ($p < 0.01$). Fentanyl can be recommended in this context.

Key words

Anaesthetic techniques, regional; epidural.
Complications; shivering.

Shaking associated with epidural anaesthesia is a common occurrence, reported in up to 50% of epidurals.[1] It is often transient and of little consequence to the mother, though occasionally it is severe enough to cause distress, and in one large series was reported to be the single most common factor in morbidity.[2] Pethidine, 25 mg in 5 ml normal saline, given epidurally has been shown effective in the alleviation of shaking within 10 minutes of administration.[3] The aim of this study was to assess fentanyl's efficacy to abolish shaking severe enough to cause complaint from or distress to the mother, whether the shaking preceded the establishment of an epidural or not.

Methods

Fifty patients whose shaking was severe enough to cause distress were allocated randomly into one of two groups. The first group received fentanyl 25 μg in 5 ml sterile normal saline and the second 5 ml saline only. Explanation of the injection was given and verbal consent obtained before the randomisation. A standardised form was completed to record: time of onset of shaking; the time shaking ceased; the time and dosage of all top-ups; the time and duration of recurrent shaking; details of the use of alternative forms of analgesia; the occurrence of nausea or vomiting. The results were analysed using Wilcoxon's Rank Sum tests and calculation of the Correlation Coefficient.

Results

Shaking occurred in under 10 minutes after epidural top-up in 14 out of 20 (70%) of the fentanyl group and in 17 out of 21 (81%) of the saline group (excluding those shaking before epidural). The median duration of shaking after epidural injection was 61 minutes in the saline group (range 5–420) versus 11 minutes in the fentanyl group (range 3–240). This was statistically significant ($p < 0.01$). Moreover, shaking was abolished in less than 15 minutes in 14 out of 20 (70%) of those who received fentanyl, but in only 3 out of 21 (14%) of the saline group. Fentanyl did not abolish shivering in five mothers, whose shaking persisted for 240, 230, 110, 90 and 90 minutes after epidural injection.

In those patients who were shaking before the epidural, five in the fentanyl group and four in the saline group, the shakes were abolished between 5 and 8 minutes after fentanyl in four out of the five, but in the fifth shaking persisted for 240 minutes. The shaking continued for 15, 90, 180, and 240 minutes after epidural injection in the saline group. This difference is not statistically significant. Epidural fentanyl was given to four patients who underwent elective epidural Caesarean section. The shaking stopped within 15 minutes in three of the four. The fourth mother shook for one hour from first top-up, until general anaesthesia was administered because of a persistent unilateral block. There was no statistically significant difference between the top-up dose of bupivacaine before shaking and the duration of shaking after epidural injection. There was no correlation either between the total dose of bupivacaine before shaking and the duration of shaking after epidural injection (Table 1).

The mothers whose shaking ceased within 15 minutes of epidural fentanyl (14 out of 20, 70%), shaking recurred in six (43%) after 45 to 120 minutes (median 65 minutes) from the fentanyl injection and lasted from 20 to 60 minutes (median 35 minutes). Shaking recurred in the saline group, in 4 out of 21 (19%) of the mothers after 90 to 212 minutes

Table 1. Influence of fentanyl on incidence and duration of shaking after epidural bupivacaine.

	Fentanyl		Saline	
Duration of shaking after injection				
Median duration (range)	11 (3–240)		61 (5–420)	
Rank sums (group numbers)	297 (20)		564 (21)*	
Recurrent shaking				
Median time from injection (range)	65 (45–120)		122.5 (90–212)	
Rank sums (group numbers)	23.5 (6)		31.5 (4)	
Median duration (range)	35 (20–60)		45 (30–60)	
Rank sums (group numbers)	29 (6)		26 (4)	
Top-up dose before shaking	25 mg	50 mg	25 mg	50 mg
Median duration of shaking after injection (range)	8 (5–90)	14 (3–270)	51 (12–210)	80 (5–420)
Rank sums (group numbers)	42 (5)**	148 (14)	66 (8)	165 (13)
Total dose before shaking				
Correlation coefficient	−0.07		−0.19	

* Statistically significant at $p < 0.01$ level.

** One mother in the fentanyl group received 37.5 mg initial top-up.

postepidural injection (median 122 minutes) and lasted from 30 to 60 minutes (median 45 minutes). This was not statistically significant. Vomiting occurred twice in the fentanyl group at 10 and 70 minutes after injection and once in the saline group (12 minutes after injection). Nausea occurred twice in the fentanyl group (11 and 30 minutes after injection) compared to three times in the saline group (45, 50 and 140 minutes after injection).

Nitrous oxide was given before the epidural in five mothers in the fentanyl group and to seven mothers in the saline group. Nitrous oxide had no influence on shaking. Pethidine 100 mg was administered to only one mother 4 hours before epidural insertion (saline group).

Discussion

The cause of shaking related to epidural analgesia is still unknown. Loss of body heat secondary to sympathetic blockade is an unlikely explanation since the onset of shaking is so rapid after epidural injection and is unusual after subarachnoid block. The evidence for causal relationship between injectate temperature and shaking is equivocal. Two studies showed no difference in the incidence of shaking when bupivacaine was warmed to body temperature, though there was a slight reduction in incidence when both the bupivacaine and the intravenous fluids were warmed.[1,4] Having tried warming bupivacaine in this unit (in an uncontrolled manner) we do not believe injectate temperature is relevant. Bromage[5] suggested that a differential block is responsible; it interrupts the warm sensation, and transmits a cold one which results in shaking. However, in this study there was no correlation between top-up dose and duration of shaking or its onset and this has been reported previously.[3]

Animal experimentation has found opioid receptors to be important in this field. Cold, shaking, anaesthetised rats stop shaking when given intraventricular beta-endorphin but this recurs when they are given naloxone.[6] Brownridge[3] demonstrated that epidural pethidine is effective in abolishing shakes, and parenterally administered pethidine reduces it after general anaesthesia.[7,8] Fentanyl given parenterally (in equipotent doses to those used above) does not reduce shaking after general anaesthesia,[8] yet as we have demonstrated is effective in its abolition when associated with epidural analgesia. This suggests a spinal cord action. Epidural fentanyl stopped the shaking when the shaking preceded epidural analgesia and also where it was associated with an epidural Caesarean section.

Acknowledgments

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References

1. Webb PJ, James FM, Wheeler AS. Shivering during epidural analgesia in women in labor. *Anesthesiology* 1981; **55:** 706–7.
2. Ostheimer GW, Datta S. Observations in the post-partum recovery room after various local anaesthetic techniques. *Regional Anaesthesia* 1981; **6:** 13–7.
3. Brownridge P. Shivering related to epidural blockade with bupivacaine in labour, and the influence of epidural pethidine. *Anesthesia and Intensive Care* 1986; **14:** 412–7.
4. Mehta P, Theriot E, Mehrotra D, Patel K, Zarbalian A. Shivering following epidural anesthesia in obstetrics. *Regional Anesthesia* 1984; **9:** 83–5.
5. Bromage PR. *Epidural analgesia.* Philadelphia: W.B. Saunders, 1978: 394–6.
6. Katsuura G, Yoshikawa K, Itoh S. Suppressive effect of beta-endorphin on body shaking response to ice water immersion and synergistic action of vasoactive intestinal peptide on beta-endorphin in anesthetised rats. *Japanese Journal of Physiology* 1983; **33:** 821–6.
7. Pauca AL, Savage RT, Simpson S, Roy RC. Effect of pethidine, fentanyl and morphine on post-operative shivering in man. *Acta Anaesthesiologica Scandinavica* 1984; **28:** 138–43.
8. Claybon LE, Hirsh RA. Meperidine arrests postanesthesia shivering. *Anesthesiology* 1980; **53:** S180.

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An evaluation of the incentive spirometer to improve lung function after cholecystectomy

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Summary

Forty patients who underwent elective cholecystectomy were allocated randomly to one of two groups. Patients in one group used an incentive spirometer as part of their postoperative chest physiotherapy; those in the other received routine postoperative physiotherapy as dictated by their needs. Each group contained equal numbers of smokers and nonsmokers, and the data from each group were analysed separately. The use of the incentive spirometer did not confer any benefits as judged by clinical evidence of pulmonary complications, pulmonary function tests or length of hospital stay.

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Key words

Complications; hypoxaemia.
Equipment; incentive spirometer.

Incentive spirometers are devices designed to encourage patients to take sustained maximal inspirations. They have been shown to reduce pulmonary atelectasis after cardiac surgery,[1,2] but evidence for their value after upper abdominal surgery is conflicting.[3–6] This study was designed to assess the benefits of incentive spirometry after cholecystectomy in terms of clinical evidence of pulmonary complications, pulmonary function tests and length of hospital stay.

Methods

Forty patients, ASA class 1 or 2, scheduled for elective cholecystectomy gave informed consent to participate in the study, which was approved by the local hospital ethics committees.

A single dose of a cephalosporin was given parenterally shortly before surgery. Premedication was with papaveretum 0.3 mg/kg and scopolamine 0.06 mg/kg given intramuscularly one hour before operation. Anaesthesia was induced with fentanyl 3–4 μg/kg and a sleep dose of thiopentone. Neuromuscular blockade was achieved with alcuronium 0.3 mg/kg, the trachea was intubated and the lungs ventilated artificially. Anaesthesia was maintained with 67% nitrous oxide in oxygen and up to 0.5% halothane as indicated clinically. Neuromuscular blockade was maintained with increments of alcuronium. Residual neuromuscular blockade at the end of surgery was antagonised with neostigmine 2.5 mg and atropine 1.2 mg. The type of incision and the length of surgery were noted. Patients who required exploration of the common bile duct were excluded from the study. No patient required a nasogastric tube.

Patients were stratified into smokers and nonsmokers and then allocated randomly to be nonusers (Group A) or users (Group B) of the Inspiron incentive spirometer. Instruction in the use of the incentive spirometer was given on the day before operation. Patients were encouraged to inhale maximally and the leak on the incentive spirometer was adjusted so that they could just maintain the ball at the top of the tube for 3 seconds. The patients were told that they should use the incentive spirometer three times every hour postoperatively and should aim to equal their pre-operative performance. All patients received routine postoperative chest physiotherapy. Postoperative analgesia was provided with intramuscular papaveretum 0.3 mg/kg as necessary.

Patients were assessed on the pre-operative day and the second postoperative day. They were questioned as to the presence of cough, sputum production or wheeze and physical examination was performed. The criteria for diagnosis of pulmonary complications were the development of productive cough, wheeze, basal crepitations or bronchial breathing. Forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were measured with a Vitalograph and peak expiratory flow rate (PEFR) with a Wright's peak flow meter. Radial arterial blood was sampled for blood gases and mixed expired oxygen and carbon dioxide were measured from a 5-minute collection of expired gas into a Douglas bag. The alveolar oxygen tension was calculated from the equation[7]

$$P\text{AO}_2 = P\text{IO}_2 - P\text{aCO}_2 \frac{P\text{IO}_2 - P\bar{\text{E}}\text{O}_2}{P\bar{\text{E}}\text{CO}_2}$$

and the alveolar–arterial oxygen tension gradient (A–aPO$_2$ difference) was calculated. The length of each patient's stay in hospital was recorded.

Within-group differences in ventilatory performance were analysed by the paired *t*-test and between-group differences by the unpaired *t*-test. Differences in evidence of pulmonary complications were analysed by the Chi-squared test and differences in length of hospital stay by the Mann–Whitney *U* test for nonparametric data. Values are expressed as mean (SD) unless stated otherwise.

Table 1. Duration of surgery expressed as median (range) and type of incision in Groups A and B.

	Group A	Group B
Duration of surgery, minutes	80 (35–140)	68 (35–110)
Paramedian incision	3	2
Subcostal incision	7	10
Transverse incision	10	8

Results

Twenty patients acted as a control group and 20 used the incentive spirometer. Ten patients in each group were smokers. The patients had an age range of 23–79 years, weight range of 44–89 kg and height range of 150–183 cm; the ranges of age, weight and height were similar in the two groups. Duration of surgery and types of incision were similar in the two groups (Table 1). All the Group B patients found the incentive spirometer easy to use. Nine patients in Group A and five patients in Group B developed clinical evidence of pulmonary complications, but this difference was not significant ($p > 0.1$).

Ventilatory measurements are summarised in Table 2. There was a highly significant ($p < 0.001$) deterioration in all measurements on the second postoperative day in both groups but there was no difference between the groups. Both groups of patients stayed in hospital for a median of 9 days; the range was 6–15 days in Group A, and 4–16 days in Group B.

Analysis of the results of all smokers in the trial showed that they had a significantly lower postoperative mean (SD) $P\text{aO}_2$ than the nonsmokers (smokers 9.02 (1.23) kPa, nonsmokers 10.16 (2.13) kPa, $p < 0.05$). The smokers had a higher postoperative A–aPO$_2$ difference (smokers 6.50 (2.17)

Table 2. Pre- and postoperative ventilatory measurements in Groups A and B expressed as mean (SD).

	Group A		Group B	
	Before operation	After operation	Before operation	After operation
FEV_1, litres	2.36 (0.65)	1.23 (0.51)	3.17 (1.02)	1.63 (0.78)
FVC, litres	3.12 (0.88)	1.64 (0.72)	4.02 (1.21)	2.15 (0.92)
PEFR, litres/minute	305 (106)	163 (72)	397 (140)	200 (101)
$P\text{aO}_2$, kPa	11.7 (1.4)	9.3 (1.2)	12.1 (1.2)	9.3 (2.3)
A–aPO$_2$, kPa	3.5 (2.0)	6.2 (2.6)	3.2 (2.1)	6.0 (2.7)

kPa, nonsmokers 5.66 (2.91) kPa), but this was not significant (p = 0.31). No other differences were observed between smokers and nonsmokers.

Discussion

Postoperative pulmonary complications are reported to occur in 18%[8]–80%[9] of patients after upper abdominal surgery; the major causative factor is considered to be shallow, monotonous tidal breathing.[10] Anaesthesia, opioid analgesia and postoperative pain can all contribute to this monotonous ventilatory pattern, devoid of the spontaneous deep breaths which occur normally every 5 or 10 minutes. Changes in pulmonary mechanics occur because of closure of basal airways[11] which is reflected in a reduction of $P\text{a}O_2$ that persists for up to 5 days postoperatively.[12] It has been suggested[13] that this postoperative hypoxaemia may be harmful even in the absence of overt pulmonary complications.

Respiratory manoeuvres intended to minimise these postoperative changes must emphasise maximum alveolar inflation and maintenance of a normal FRC. The ideal manoeuvre is a sustained maximal inspiration.[10] Devices which induce the patient to make a sustained maximal inspiration are called incentive spirometers and range from elaborate electronic devices with a system of lights to indicate inspiratory performance, to simple portable disposable instruments with a plastic ball which rises in a tube. The 'Inspiron' incentive spirometer is for single patient use and has an adjustable leak which alters the flow rate required to raise a plastic ball to the top of a tube and hold it there. Patients are instructed pre-operatively to adjust the leak until their inspiratory effort is just sufficient to hold the ball at the top of the tube for 3 seconds; postoperatively, they are encouraged to match their preoperative performance.

Early reports on the use of the original Bartlett Edwards incentive spirometer after abdominal surgery were encouraging; Bartlett *et al.*[3] showed a significantly reduced incidence of abnormal postoperative chest radiographs in patients who used the incentive spirometer. Craven *et al.*[4] reported a significant improvement in both radiological changes and clinical evidence of pulmonary complications. However, Lyager *et al.*[5] and Schwieger *et al.*[6] were unable to show any benefit from the use of the incentive spirometer after a variety of upper abdominal procedures, although Lyager *et al.* attributed this to the overall low rate of postoperative pulmonary complications. In the present study, we used the relatively cheap Inspiron device and evaluated its use as an adjunct to routine physiotherapy in both smokers and nonsmokers. In addition to the criteria used by other authors we calculated the increase in alveolar–arterial oxygen tension gradient; this could be the result of any degree of postoperative alveolar collapse.

Our patients all found the device acceptable, in contrast with those in other studies,[14] and several used it with great enthusiasm. They had a 35% incidence of postoperative pulmonary complications and we confirmed the considerable deterioration in pulmonary mechanics that occurs after upper abdominal surgery. FVC, FEV_1 and PEFR decreased to approximately 50% of their pre-operative values and A–a$P\text{O}_2$ difference doubled by the second postoperative day. There was no statistically significant difference in pulmonary complications between the groups in our study. However, the Group B patients had fewer complications than those in Group A, and this raises the possibility that we have rejected incorrectly the null hypothesis that there is no difference between the groups (a type II error); indeed, the Chi-squared test that we have used has a relatively low power of 0.23. Nevertheless if the trend for the Group B patients to have fewer complications had continued it would have become statistically significant only after 120 patients had entered the trial. In addition, we were unable to show any other benefit attributable to the incentive spirometer, and we cannot recommend the routine use of such a device as an addition to routine chest physiotherapy following upper abdominal surgery.

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References

1. PRINS LS. An evaluation of incentive breathing as a prevention of atelectasis in open heart patients. *Respiratory Technology* 1978; **14:** 9–10, 22–3.
2. IVERSON LIG, ECKER RR, FOX HE, MAY IA. A comparative study of IPPB, the incentive spirometer, and blow bottles: the prevention of atelectasis following cardiac surgery. *Annals of Thoracic Surgery* 1978; **25:** 197–200.
3. BARTLETT RH, BRENNAN ML, GAZZANIGA AB, HANSON EL. Studies on the pathogenesis and prevention of postoperative pulmonary complications. *Surgery, Gynecology and Obstetrics* 1973; **137:** 925–33.
4. CRAVEN JL, EVANS GA, DAVENPORT PJ, WILLIAMS RHP. The evaluation of the incentive spirometer in the management of postoperative pulmonary complications. *British Journal of Surgery* 1974; **61:** 793–7.
5. LYAGER S, WERNBERG M, RAJANI N, BOGGILD-MADSEN B, NIELSEN L, NIELSEN HC, ANDERSEN M, MOLLER J, SILBERSCHMID M. Can postoperative pulmonary conditions be improved by treatment with the Bartlett–Edwards incentive spirometer after upper abdominal surgery? *Acta Anaesthesiologica Scandinavica* 1979; **23:** 312–9.
6. SCHWIEGER I, GAMULIN Z, FORSTER A, MEYER P, GEMPERLE M, SUTER PM. Absence of benefit of incentive spirometry in low-risk patients undergoing elective cholecystectomy. A controlled randomized study. *Chest* 1986; **89:** 652–6.
7. NUNN JF. Indirect determination of the ideal alveolar oxygen tension during and after nitrous oxide anaesthesia. *British Journal of Anaesthesia* 1963; **35:** 8–10.
8. MCCABE R, REID WM, KNOX WG. Evaluation of the use of a temporary percutaneous endotracheal catheter in the treatment and prevention of postoperative pulmonary complications. *Annals of Surgery* 1962; **156:** 5–11.
9. LASZLO G, ARCHER GG, DARRELL JH, DAWSON JM, FLETCHER CM. The diagnosis and prophylaxis of pulmonary complications of surgical operation. *British Journal of Surgery* 1973; **60:** 129–34.
10. BARTLETT RH, GAZZANIGA AB, GERAGHTY TR. Respiratory maneuvers to prevent postoperative pulmonary complications. A critical review. *Journal of the American Medical Association* 1973; **224:** 1017–21.
11. ALEXANDER JI, SPENCE AA, PARIKH RK, STUART B. The role of airway closure in postoperative hypoxaemia. *British Journal of Anaesthesia* 1973; **45:** 34–40.
12. KNUDSEN J. Duration of hypoxaemia after uncomplicated upper abdominal and thoraco-abdominal operations. *Anaesthesia* 1970; **25:** 372–7.
13. FRIEDMAN GD, KLATSKY AL, SIEGELAUB AB. Lung function and risk of myocardial infarction and sudden cardiac death. *New England Journal of Medicine* 1976; **294:** 1071–5.
14. LEDERER DH, VAN DE WATER JM, INDECH RB. Which deep breathing device should the postoperative patient use? *Chest* 1980; **77:** 610–3.

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Cricoid pressure and the pressor response to tracheal intubation

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Summary

Forty healthy adults who underwent rapid sequence induction of anaesthesia were allocated randomly to receive either cricoid pressure or its simulation. The anticipated increase in systolic arterial pressure and heart rate after laryngoscopy and tracheal intubation were not altered significantly by the application of cricoid pressure.

Key words

Larynx; cricoid pressure.
Intubation, tracheal; complications.

Dysrhythmias following tracheal intubation were reported in 1940,[1] and 10 years later it was proposed that their cause was sympathetic stimulation.[2] The next year, sudden increases of arterial pressure and heart rate (HR) caused by laryngoscopy and tracheal intubation were described[3] and they have become known collectively as the pressor response (PrR). The proposition of sympathetic mediation is supported by the association of the PrR with an increase in concentration of circulating catecholamines.[4–6] Both phenomena start seconds after laryngoscopy begins and are caused probably by the pressure of the laryngoscope blade rather than by tracheal intubation.[7,8]

The majority of adult patients are protected from regurgitation of stomach contents if cricoid pressure (CP) is applied by means of an external force of 44N during induction of anaesthesia.[9] During CP, the tissues that surround the vallecula are forced into closer contact with the laryngoscope blade and the pressure it exerts is inevitably increased. We studied the effect of CP on the PrR measured noninvasively during rapid sequence induction of anaesthesia.

Methods

Forty healthy adults (31 female) who underwent elective surgery under general anaesthesia were studied; they were not at special risk from regurgitation of stomach contents. Approval by the hospital ethics committee and patients' informed consent were obtained. Each patient received temazepam 10–20 mg orally 90 minutes before surgery and was allocated randomly to receive either CP application or its simulation. A 19-gauge needle was inserted in the patient's left hand and pre-oxygenation begun, before induction of anaesthesia. Heart rate, calculated from a precordial electrocardiograph, and indirect systolic arterial pressure (SAP), measured with a mercury sphygmomanometer, were recorded at 15-second intervals. An external Döppler flow probe was used to define the systolic endpoint; the signal was fed into headphones and the results were dictated to a domestic cassette recorder. After 150 seconds, anaesthesia was induced over 15 seconds with thiopentone 6 mg/kg and tracheal intubation was facilitated by suxamethonium 1.5 mg/kg. CP was applied or simulated as the patient lost consciousness. The cricoid yoke applicator consisted of two weights attached to a strip of perspex which was in turn attached to a moulded plastic pad that conformed to the external shape of the adult cricoid cartilage (Fig. 1); its total weight was 4.5 kg. The weighted ends of the yoke were held by the outstretched fingers of the assistant's hands and its full weight was lowered centrally on to the external landmark of the cricoid cartilage. Simulation was achieved by holding the weight just above this point with the assistant's hands in the same posture as for application. Neither the anaesthetist (J.C.) nor recording technician (T.P.) knew whether CP had been applied or simulated.

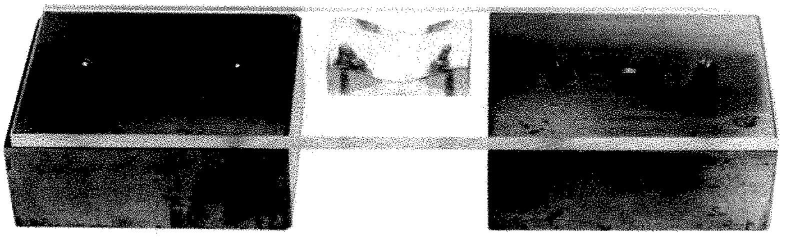

Fig. 1. The simple cricoid yoke.

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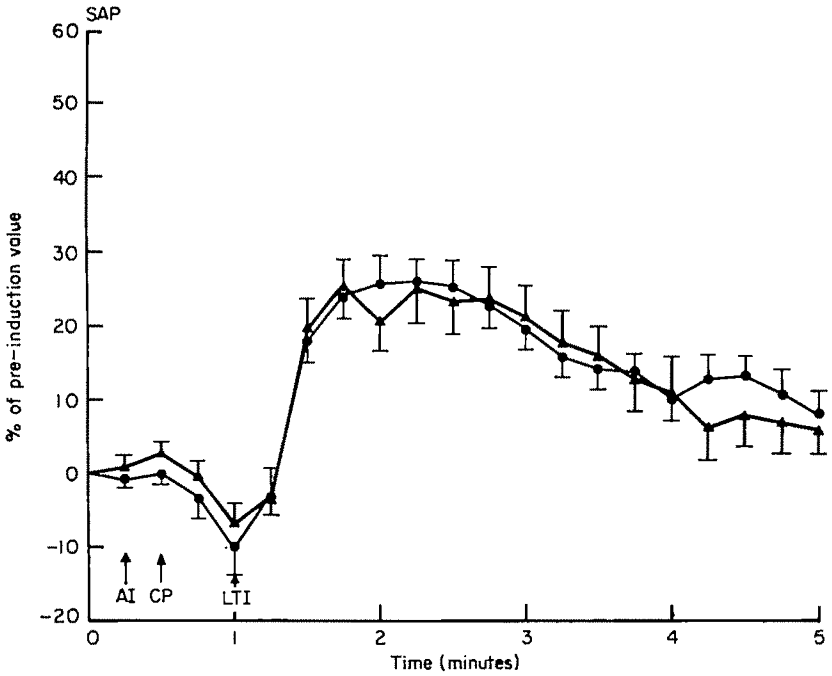

Fig. 2. Percentage changes in systolic arterial pressure (SAP) during induction and laryngoscopy and tracheal intubation with and without CP application. AI, anaesthesia induction; CP, cricoid application or simulation; LTI, laryngoscopy and tracheal intubation. ●, cricoid pressure; ▲, no cricoid pressure.

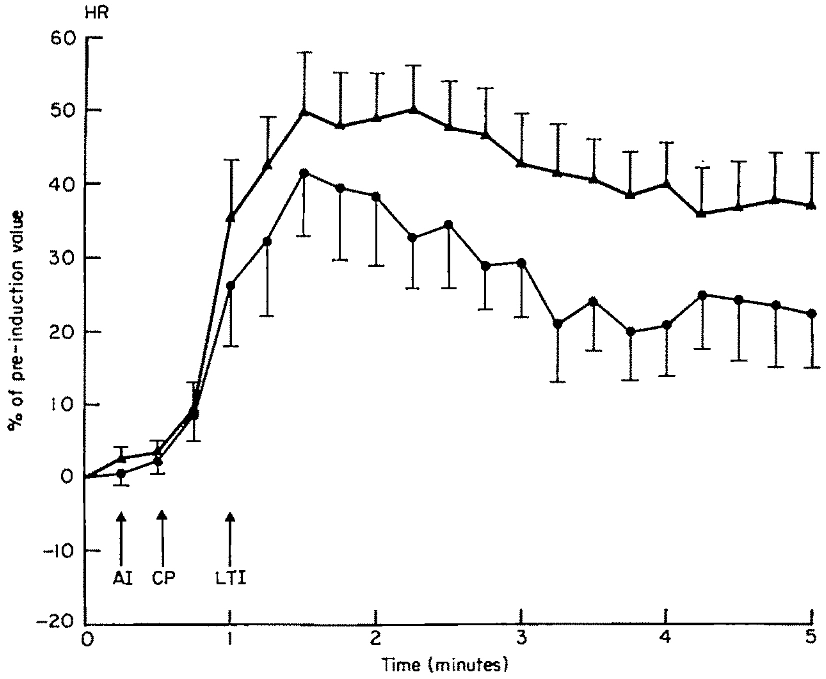

Fig. 3. Percentage changes in heart rate (HR) during induction laryngoscopy and tracheal intubation with and without CP application. Abbreviations and symbols as for Fig. 1.

Laryngoscopy and tracheal intubation started 45 seconds after induction and were standardised to take 15 seconds. The tracheal tube cuff was inflated immediately after intubation, and the lungs ventilated manually with 33% oxygen in nitrous oxide to maintain an end-tidal carbon dioxide tension of 4.5 kPa. Heart rate and SAP measurements continued at 15-second intervals for 3 minutes during which time no other disturbance of the patient was permitted. The pre-induction HR and SAP for each subject were converted to a nominal value of 100 for graphic display and statistical analysis and subsequent measurements expressed as a percentage of the pre-induction reading. Analysis of variance was performed using a generalised linear model on a Vax 11/780 mainframe computer.

Table 1. Demographic details; values expressed as mean (SD).

	Cricoid pressure	Control
Number of patients	20	20
Age, years	41.8 (11.5)	43.3 (14.7)
Weight, kg	65.4 (10.0)	63.8 (9.3)
Pre-induction SAP, mmHg	120.3 (21.0)	122.0 (22.5)
Pre-induction HR, beats/minute	81.6 (21.5)	75.3 (18.4)

SAP, systolic arterial pressure; HR, heart rate.

Results

Patients in the two groups were of similar age and weight and there were no significant differences between their pre-induction SAP or HR (Table 1). SAP decreased and HR increased in both groups after induction. Both parameters increased markedly immediately after laryngoscopy and tracheal intubation (Figs 2 and 3) to reach maximum values between 90 and 120 seconds after intubation; subsequently both decreased gradually. The maximum value of SAP was 126% of the pre-induction value in both groups. HR increased by 50% in the group in which CP was simulated compared with 41% in the group in which CP was applied. The HR for the CP group was less than that for the simulated CP group at all times after intubation, but this trend did not achieve statistical significance.

Discussion

The application of CP in this study did not augment the PrR that normally follows tracheal intubation. The PrR to laryngoscopy and tracheal intubation may cause myocardial ischaemia, rupture of intracranial aneurysm, left ventricular failure and sudden changes in intracranial pressure.[10–12] Many techniques have been reported to attenuate the PrR and have been well reviewed by Ng.[13] The decision to select one of these techniques should be based on an estimate of the likely magnitude of the PrR, admittedly a difficult task, and the specific vulnerability of the patient to its effects. Many patients who present for emergency anaesthesia, and in whom CP application may be indicated, are at risk of these potential effects of the PrR. The pressure recorded by a strain gauge mounted on the tip of the laryngoscope blade is increased during difficult intubation and this pressure is of the order of magnitude of that applied during effective CP.[14] There is also some evidence that a greater than average PrR may be expected when tracheal intubation is facilitated by external laryngeal manipulation.[15]

A more sophisticated device which allows application of a variable and measured force has been reported[16] since the original description of the cricoid yoke.[9] Our yoke was similar to the original pattern in that a known weight (4.5 kg) is applied externally to the cricoid cartilage and produces a calculable force (44N). This force is transmitted by the cartilage to produce an increase in cricopharyngeal pressure which is likely to afford protection from the regurgitation of stomach contents. This results in a standardised technique similar to that applied in clinical practice. We chose noninvasive monitoring because it was simple. The timescale and pattern of the PrR are such that noninvasive techniques should reflect accurately the changes in HR and SAP, although clearly beat-to-beat variation is missed. We were able to record consistently at 15-second intervals by recording only the systolic component of pressure and we believe that this is adequate.

The increase in the PrR was less than we had expected. It may be that the stimulus provided by intubation is already near maximal in respect of SAP. Shribman *et al.* were unable to demonstrate any differences in the SAP component of the PrR or the increases in concentration of circulating catecholamines when patients who underwent laryngoscopy alone were compared with those in whom laryngoscopy was followed by tracheal intubation, but they did find that increases in HR occurred only if laryngoscopy was followed by intubation.[8] They suggested that laryngoscopy produced a balanced stimulation of vagal and cardiac accelerator fibres. It is tempting to agree and to suggest that the balance during CP may be shifted to emphasise the component played by laryngoscopy, which is manifested as a vagally-mediated trend to a lesser increase in HR than when CP is not applied. The 'vagal component' explanation for the PrR has been offered previously, especially when older techniques of anaesthesia were used[1] and when children who received halothane anaesthesia were studied,[17] but this does not detract from the concept of an essentially sympathetically mediated response.

There is no reason based on our findings to suggest that the PrR when CP is applied properly is any greater than would be predicted normally. Attenuation of the response is not indicated simply because CP is applied.

References

1. Reid LC, Brace DE. Irritation of the respiratory tract and its reflex effect upon the heart. *Surgery, Gynecology and Obstetrics* 1940; **70**: 157–62.
2. Burstein CL, Piazza TL, Kappa LA, Rovenstine EA. Cardiocirculatory disturbances during intrathoracic surgery. *Surgery* 1949; **25**: 36–46.
3. King BD, Harris LC, Greifenstein FE. Cardiovascular effects of orotracheal intubation during light anaesthesia. *Surgical Forum* 1950; **1**: 620–4.
4. Russell WJ, Morris RG, Frewin DB, Drew SE. Changes in plasma catecholamine concentrations during endotracheal intubation. *British Journal of Anaesthesia.* 1981; **53**: 837–9.
5. Low JM, Harvey JT, Prys-Roberts C, Dagnino J. Studies of anaesthesia in relation to hypertension VII: Adrenergic response laryngoscopy. *British Journal of Anaesthesia* 1986; **58**: 471–7.
6. Derbyshire DR, Chmielewski A, Fell D, Vater M, Achola K, Smith G. Plasma catecholamine responses to tracheal intubation. *British Journal of Anaesthesia* 1983; **55**: 855–60.
7. Stoelting RK. Circulatory changes during laryngoscopy and tracheal intubation. Influence of duration of laryngoscopy with or without prior lidocaine. *Anesthesiology* 1977; **47**: 381–3.
8. Shribman AJ, Smith G, Achola KJ. Cardiovascular and catecholamine responses to laryngoscopy with and without tracheal intubation. *British Journal of Anaesthesia* 1987; **59**: 295–9.
9. Wraight WJ, Chamney AR, Howells TH. The determination of an effective cricoid pressure. *Anaesthesia* 1983; **38**: 461–6.
10. Prys-Roberts C, Greene LT, Meloche R, Foex P. Studies of anaesthesia in relation to hypertension II: Haemodynamic consequences of induction and endotracheal intubation. *British Journal of Anaesthesia* 1971; **43**: 531–46.
11. Fox EJ, Sklar GS, Hill CH, Villanueva R, King BD. Complications related to the pressor response to endotracheal intubation. *Anesthesiology* 1977; **47**: 524–5.
12. Shapiro HM, Galindo A, Wyte SR, Harris AB. Acute intracranial hypertension during anaesthetic induction. Partial control with thiopental. Proceedings of the fifth International Symposium of Cerebral blood flow and intracranial pressure. Roma-Siena 1971. *European Neurology* 1972; **8**: 118–21.
13. Ng WS. Pathological effects of tracheal intubation. In: Latto IP, Rosen M, eds. *Difficulties in tracheal intubation.* London: Ballière Tindall, 1985; 14–20.
14. Scheck PAE. Measurements of the pressure of the laryngoscope during endotracheal intubation. *Anaesthesia* 1982; **37**: 370.

15. CURRAN J. The pressor response to laryngoscopy and tracheal intubation. PhD thesis: National University of Ireland 1983.
16. LAWES EG, DUNCAN PW, BLAND B, GEMMEL L, DOWNING JW. The cricoid yoke—a device for providing consistent and reproducible cricoid pressure. *British Journal of Anaesthsia* 1986; **58:** 925–31.
17. REINIKAINEN M, PONTINEN P. On cardiac arrthymias during anaesthesia and surgery. *Acta Medica Scandinavica* 1966; **180** (Suppl. 457): 5–36.

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Nifedipine and surgical removal of phaeochromocytoma

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Summary

The management of five patients with phaeochromocytoma undergoing surgical removal is described. Pre-operative preparation with phenoxybenzamine and nifedipine for 7 days before surgery prevented excessive fluctuations in cardiovascular parameters in the peri-operative period and resulted in an uneventful recovery.

Key words

Pharmacology; nifedipine, phenoxybenzamine.
Surgery; phaeochromocytoma.

Anaesthetic management for the surgical removal of phaeochromocytoma is a challenge to the anaesthetist. The introduction of alpha- and beta-adrenergic antagonists,[1,2] sodium nitroprusside, pre-operative volume expansion[3] and better anaesthetic drugs and techniques have minimised hazards. These result from excess catecholamine secretion and its sudden depletion after surgical removal of phaeochromocytoma.[4,5] In our experience even the well prepared patient suffers episodes of severe hyper and hypotension, tachycardia and cardiac dysrythmias during patient positioning, preparation of the surgical field, tracheal intubation, and manipulation and excision of the tumour.

Nifedipine has been used effectively in the recent past in patients with essential hypertension.[6] In addition, its efficacy in the control of hypertension complicated by heart failure, particularly in older patients, is well described.[7,8] However, its usefulness in the management of patients scheduled for the surgical removal of phaeochromocytoma has not been previously described to our knowledge. This article highlights nifedipine's ability to provide a smooth cardiovascular status peri-operatively when it is administered with phenoxybenzamine for 7 days in the pre-operative preparation of the patient.

Case histories

Case 1. A forty-four year old male who weighed 80 kg was admitted to our hospital. He had a six-month history of episodic headache, syncopal attacks for 2.5 months and hyperaesthesia over the left leg. On admission his arterial blood pressure and pulse rate were 190/120 mmHg and 100 beats/minute. Hypertension was controlled with oral alpha methyl dopa 250 mg 6-hourly, hydrallazine 25 mg 12-hourly and frusemide 40 mg once a day. Diagnosis of

Table 1. Pre-operative parameters.

Patient No.	Age/ Sex	Weight (kg)	Pulse (beats/minute)	Blood pressure (mmHg)	VMA excretion (μmol/24 hours)	Hypertensive crises
1	44 M	80	100	190/120	86.7	—
2	26 M	54	120	200/160	122.4	Two-SNP used
3	37 M	63	130	220/120	102.0	—
4	35 F	42	102	230/120	119.3	—
5	28 M	72	92	140/90	74.6	—

VMA, Vanillyl mandelic acid (normal excretion <25 μmol/24 hours).

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Table 2. Pre-operative preparation.

	Antihypertensive treatment							Volume expansion before operation			Pre-operative	
Patient No.	Atenolol	Alpha methyl dopa	Hydral-azine	Frusemide	Captopril	Nifedipine	Phenoxy-benzamine	Pre-operative SNP for crises	Blood	Plasma	Pulse beats/minute	Mean arterial pressure mmHg
1	—	250 mg/ 6 hourly	25 mg/ 12 hourly	40 mg/ 24 hourly	—	10 mg/ 8 hourly	10 mg/ 6 hourly	—	1 unit/4 days before operation	1 unit/2 days before operation	72	130
2	—	250 mg/ 6 hourly	25 mg/ 8 hourly	40 mg/ 24 hourly	—	10 mg/ 8 hourly	20 mg/ 6 hourly	yes	2 units/5 and 3 days before operation	—	80	140
3	—	250 mg/ 6 hourly	25 mg/ 12 hourly	40 mg/ 24 hourly	—	15 mg/ 8 hourly	10 mg/ 6 hourly	—	2 units/5 and 3 days before operation	1 unit/2 days before operation	90	108
4	100 mg/ 24 hourly	250 mg/ 6 hourly	25 mg/ 12 hourly	40 mg/ 24 hourly	—	10 mg/ 8 hourly	10 mg/ 6 hourly	—	1 unit/5 days before operation	1 unit/3 days before operation	102	140
5	—	250 mg/ 6 hourly	25 mg/ 12 hourly	40 mg/ 24 hourly	25 mg/ 12 hourly	5 mg/ 8 hourly	10 mg/ 8 hourly	—	1 unit/5 days before operation	1 unit/2 days before operation	78	110

SNP = sodium nitroprusside

phaeochromocytoma was confirmed by urinary vanillyl mandelic acid (VMA) excretion of 86.7 μmol/24 hours. A left adrenal tumour was localised by ultrasound and computed tomography.

Case 2. A twenty-six year old male who weighed 54 kg was admitted with suspected phaeochromocytoma after a typical history of episodic headaches and palpitations on exertion. His blood pressure ranged between 200/160–180/120 mmHg and pulse rate 100–120 beats/minute. His hypertension was controlled with oral administration of alpha methyl dopa 250 mg 6-hourly, hydralazine 25 mg 8-hourly and frusemide 40 mg once a day. His two hypertensive crises were controlled with sodium nitroprusside infusion. The diagnosis was confirmed by a measured urinary VMA of 122.4 μmol/24 hours. A right adrenal mass was localised with the help of computed tomography.

Case 3. A thirty-seven year old male who weighed 63 kg with a history of severe hypertensive bouts, blurred vision, headache and vomiting for 8 months was admitted with a diagnosis of malignant hypertension. Hypertensive bouts, 220/120 mmHg, pulse rate −130 beats/minute, were accompanied with severe abdominal pain. Oral administration of nifedipine 15 mg 8-hourly, alpha methyl dopa 250 mg 6-hourly and hydralazine 25 mg 12-hourly, controlled his blood pressure to the range 140/90–160/110 mmHg and pulse rate 82–100 beats/minute. Diagnosis of phaeochromocytoma was made on the basis of urinary VMA of 102 μmol/24 hours. A right adrenal mass was localised on computed tomography.

Case 4. A thirty-five year old female who weighed 42 kg was admitted with complaints of a 2-month history of headache and giddiness on standing. On admission, her blood pressure was 230/120 mmHg while supine and 160/80 mmHg on standing. Fundii showed bilateral arteriolar narrowing. Oral administration of atenolol 100 mg/24 hours and frusemide 40 mg/24 hours controlled her hypertension. Laboratory investigations revealed a urinary VMA of 119.3 μmol/24 hours. Aortogram and computed tomography located the tumour as a left supra renal mass.

Case 5. A twenty-eight year old male who weighed 72 kg was admitted with a history of headache and episodic palpitations. On investigation, his urinary VMA excretion of 74.6 μmol/24 hours suggested phaoechromocytoma. Intravenous pyelography and computed tomography indicated an extra-adrenal tumour, retroperitoneal and anterior to the right ureter near the inferior vena cava. He was prescribed oral captopril 25 mg/12 hourly and hydralazine 25 mg 12-hourly.

Pre-operative preparation. Seven to 10 days before surgery, the patients were prescribed oral phenoxybenzamine 10–20 mg 6-hourly and nifedipine 5–15 mg 8-hourly together with antihypertensive drugs already being administered. Mean arterial pressure was controlled to a range of 108–140 mmHg and pulse rates to 72–120 beats/minute. Blood volume expansion was achieved by the patients receiving blood (1–2 units) and plasma (1 unit) 2–5 days before surgery.

Peri-operative management. Patients were sedated with oral diazepam 5 mg 12-hourly, started 48 hours before surgery; phenoxybenzamine, nifedipine and diazepam were also given orally, 3 hours before surgery. An intravenous line was secured under local anaesthetic, lignocaine 2%, and a microdrip delivered normal saline which contained 50 mg sodium nitroprusside 100 μg/ml at the rate of 4–6 micro drops a minute. This kept the intravenous line patent and effected rapid control of the 'surges', with a higher flow rate as and when required. Patients were premedicated one hour before surgery with an intramuscular injection of morphine sulphate 0.2 mg/kg body weight, and promethazine hydrochloride 0.4 mg/kg body weight. The patients

Table 3. Intra-operative medication.

Intra-operative requirements							After tumour removal		After operation	
Patient No.	Verapamil, mg	Sodium nitroprusside	Propranolol, mg	Blood units	Plasma units	Crystalloids	Pulse/ minute	Mean arterial pressure mmHg	Sodium nitroprusside	Nifedipine
1	—	5 mg	—	1	—	750 ml	77	110	for 24 hours	5 mg/ 8 hourly
2	—	2.5 mg	—	1	—	1000 ml	88	80	—	—
3	—	2.5 mg	—	1	—	1000 ml	96	70	—	—
4	—	3.5 mg	1.6 mg	3	—	2000 ml	100	80	for 24 hours	5 mg/ 8 hourly
5	2 mg	15 mg	—	2	1	1000 ml	88	110	—	—

were transferred to the pre-anaesthesic room; care was taken to avoid precipitation of any increase in blood pressure/pulse rates. They were then moved to the operating table and connected to the ECG monitor and an automatic blood pressure instrument which functioned on the oscillotonometric principle; it recorded systolic, diastolic and mean pressure and pulse rates continuously. Percutaneous radial artery and basilic vein cannulation was performed under local anaesthesic, connected to the four-channel monitor by way of transducers to record continuously direct arterial and central venous pressures.

Anaesthesia was induced with morphine sulphate 3 mg, pancuronium bromide 0.1 mg/kg body weight and sodium thiopentone 5 mg/kg body weight. The patients' lungs were ventilated for 3 minutes with the Siemens Elema 900B Servo Ventilator (Sweden) using 70% nitrous oxide in oxygen, in conjunction with the CO_2 Analyser 930. Ninety seconds before tracheal intubation, intravenous lignocaine 1.5 mg/kg body weight was administered and under direct vision the trachea was intubated with a low pressure cuffed tube of appropriate size. Other parameters monitored were end-tidal carbon dioxide, blood gases for acid base balance, electrolytes and urine output. Increases in arterial pressure were controlled with sodium nitroprusside infusion during the anaesthetic and surgical procedure and increases in pulse rate with either propranolol or verapamil. Decreases in arterial and central venous pressure were treated by blood/normal saline tranfusion. Dextrose 5% infusion was avoided before excision of the tumour to prevent any increase/compounding of hyperglycaemia associated with elevated catecholamine levels. Estimated blood loss was replaced. The residual effect of muscle relaxant was reversed at the end of surgery with neostigmine and atropine. None of the five patients required postoperative ventilation or a noradrenaline drip to increase their blood pressure.

They were discharged on the eighth day after operation following an uneventful recovery. Two of the five who required sodium nitroprusside postoperatively for up to 12 hours were prescribed oral nifedipine (5 mg/8-hourly) on discharge to control their residual hypertension. One patient, case 5, showed increased fluctuation in arterial pressure and pulse rate peri-operatively.

Discussion

In our experience even well prepared patients suffer episodes of severe hypertension, tachycardia and cardiac dysrhythmias during moving, preparation of the surgical area, tracheal intubation, positioning and manipulation of the tumour.

Hull, in a recent review,[5] described important aspects of anaesthetic management for the surgical excision of phaeochromocytoma, but use of nifedipine in such management has yet to be documented. Lenders[9] described nifedepine's effects in the control of haemodynamic 'surges' as a result of excess catecholamines in cases of phaeochromocytoma of the bladder.

Patients in our series administered nifedipine and phenoxybenzamine in addition to other antihypertensive drugs for 7–10 days pre-operatively demonstrated minimal peri-operative fluctuations in blood pressure and pulse rates. The marked absence of significant alterations in pulse rate (except in case 5), despite mild fluctuations in blood pressure can be attributed to nifedipine's ability to reduce arterial pressures at low doses without significantly increasing the heart rate.[10] The relative increase in arterial pressure and heart rate in case 5 can probably be attributed to captopril which was used pre-operatively for blood pressure control (unlike alpha methyl dopa in other patients). It has been shown that captopril does not counteract circulating catecholamines.[11]

In cases of phaeochromocytoma where phenoxybenzamine is used for reduction of arterial pressure, severe tachycardia and other dysrhythmias occur which generally require control with beta blockers. However, beta blockers can be administered only after full alpha receptor blockade has been achieved to avoid precipitating hypertensive crises and pulmonary oedema[12,13] especially in patients with an already compromised myocardium.[4] Beta-receptor blockers also tend to produce severe bradycardia in between 'surges'[5] especially in patients with increased episodic hypertension and tachycardia. Prazosin has shown to be better than phenoxybenzamine, but it has its own limitations and cannot be used as the drug of first choice.[14]

In summary, our study shows that if nifedipine is given together with phenoxybenzamine for 7–10 days before the surgical removal of phaeochromocytoma, it ameliorates not only the tachycardia and possibly other dysrhythmias but also provides a smoother haemodynamic status during the anaesthetic and surgical procedure. Nifedipine has some advantages over beta blockers in patients with an already compromised myocardium.[15,16] It may also be used safely in phaeochromocytoma patients with associated bronchial asthma.

References

1. Hoffman BB, Lefkowitz RJ. Alpha-adrenergic receptor subtypes. *New England Journal of Medicine* 1980; **302:** 1390–6.
2. Perry LB, Gould AB. The anesthetic management of pheochromocytoma: effect of preoperative adrenergic blocking drugs. *Anesthesia Analgesia* 1972; **51:** 36–4.
3. Deorbo GA Jr, Stewart BH, Tarazi RC, Gifford RW Jr. Preoperative blood transfusion in the safe surgical management of pheochromocytoma: a review of 46 cases. *Journal of Urology* 1974; **111:** 715–21.
4. Chari P, Katariya RN, Singh H. Anaesthetic management for the surgical removal of phaeochromocytoma (a case report). *Indian Journal of Anaesthesia* 1977; **25:** 412–5.
5. Hull CJ. Phaeochromocytoma—diagnosis, preoperative preparation and anaesthetic management. *British Journal of Anaesthesia* 1986; **58:** 1453–68.

6. MacGregor GA, Markandur ND, Bayliss J, Brown M, Roulston JE. Circumstantial evidence that an abnormality of calcium transport may be important in essential hypertension. *Clinical Science* 1981; **60:** 6P–7P.
7. Guazzi M, Olivari MT, Polese A, Fiorentini C, Magrini F, Moruzzi P. Nifedipine, a new antihypertensive with rapid action. *Clinical Pharmacology and Therapeutics* 1977; **22:** 528–32.
8. Aoki K, Kondo S, Mochizuki A, Yoshida T, Kato S, Kato K, Takikawa K. Antihypertensive effect of cardiovascular Ca^{2+}–antagonist in hypertensive patients in the absence and presence of beta–adrenergic blockade. *American Heart Journal* 1978; **96:** 218–26.
9. Lenders JWM, Sluiter HE, Thein Th, Willemsen J. Treatment of a phaeochromocytoma of the urinary bladder with nifedipine. *British Medical Journal* 1985; **290:** 1624–5.
10. Guintoli F, Guidi G, Scalabrino A, Galeone F, Pegliai E, Morihi S, Birindelli A, Saba P. Nifedipine as single drug therapy in hypertension. *Current Therapeutic and Research* 1981; **30:** 447–52.
11. Miller EJ Jr. New concepts of blood pressure control and treatment. In: Kaplan JA, ed. *Cardiac Anaesthesia* Vol. II. Orlando: Grune & Stratton, 1983: 379–381.
12. Wark J. Larkins RG. Pulmonary oedema after propranolol therapy in two cases of phaeochromocytoma. *British Medical Journal* 1978; **1:** 1395–6.
13. Sloand EM, Taylor Thompson B. Propranolol-induced pulmonary edema and shock in a patient with pheochromocytoma. *Archives of Internal Medicine* 1984; **144:** 173–4.
14. Graham RM, Thornell IR, Gain JM, Bagnoli C, Oates HF, Stokes GS. Prazocin: the first-dose phenomenon. *British Medical Journal* 1976; **2:** 1293.
15. Stone PH, Antman EM, Muller JE, Braunwald E. Calcium channel blocking agents in the treatment of cardiovascular disorders. Part II. Hemodynamic effects and clinical applications. *Annals of Internal Medicine* 1980; **93:** 886–904.
16. Braunwald E. Mechanism of action of calcium-channel-blocking agents. *New England Journal of Medicine* 1982; **307:** 1618–27.

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Responsibility for the Consent form

Dr Palmer's Editorial (*Anaesthesia* 1988; **43:** 265–6) is both informative and important. He suggests that in difficult cases, but apparently not routinely, the senior clinician should obtain the written consent. How does the hospital relate to this matter? Practice varies enormously in the private sector. In some hospitals the patient cannot be sent to the operating theatre without a signed consent. In others, major procedures are performed routinely without a consent form, and I know of one place where there is often no record of the anaesthesia for open heart surgery! What is the legal situation so far as the hospital is concerned, in case there is litigation related to, say, a wrong operation or unexpected complications? In short, is it the doctor's responsibility alone to obtain written consent and no concern of the hospital if he fails to do so?

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Letters must be typewritten on one side of the paper only and double spaced with wide margins. Copy should be prepared in the usual style and format of the Correspondence section. Authors must follow the advice about references and other matters contained in the Notice to Contributors to *Anaesthesia* printed at the back of each issue. The degrees and diplomas of each author must be given in a covering letter personally signed by all the authors.

Correspondence presented in any other style or format may be the subject of considerable delay and may be returned to the author for revision. *If the letter comments on a published article in* Anaesthesia, *please send three copies; otherwise two copies of your letter will suffice.*

A reply

Thank you for allowing an opportunity to comment upon the letter from Dr Gilston.

The duty to counsel and to inform rests with the clinician, not with the hospital (whether NHS or Private). It was hoped that the House of Lords would give a ruling on the possibility (raised by the Vice-Chancellor, Sir Nicolas Browne-Wilkinson, in the case of *Wilsher v. Essex Health Authority*, TLR 6 August 1986, 1987 QB 730) that Health Authorities might have a direct (as distinct from a vicarious) responsibility for medical staff in certain circumstances. In the event, however, the House of Lords remitted the case for retrial and so the point was not pursued.

There may be a shared apportionment of liability between doctors, nurses and others, in the case of wrong operations and each case would be assessed on its own particular facts. The law requires that a reasonable standard of care is provided and that a safe system of practice is in operation to guard against basic errors such as operations on the wrong patient, limb or side.

One is dismayed to think surgical and anaesthetic procedures are undertaken with no written record! The occurrence of problems (recognised complication or otherwise) provides fertile soil for complaints and claims. The absence of a full and accurate contemporaneous record makes the defence of such cases extremely difficult if not impossible. The protection and defence organisations constantly remind their members of the importance of good contemporaneous records.

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Postoperative pain: a comparison of laparoscopic sterilisation and diagnostic laparoscopy

Laparoscopic sterilisation (LS) and diagnostic laparoscopy (DL) are performed frequently on a daycase basis. It is assumed, but not proven, that LS is more painful afterwards than DL,[1] and may therefore be less suitable for day surgery. However, these women have domestic commitments and may prefer daycase surgery.

Most laparoscopy patients need analgesia which is both parenteral, and stronger than paracetamol or nonsteroidal anti-inflammatory drugs, but recovery and street-fitness after narcotic analgesics in daycase patients have not yet been investigated.[2] We undertook a study to determine whether there is a difference in postoperative pain between LS and DL, and to assess the efficacy of our postoperative analgesic regimen. We used codeine phosphate 60 mg intramuscularly or paracetamol 1 g orally for pain relief after laparoscopy at that time in our Day Surgery Unit. Intramuscular papaveretum 10 mg was administered if codeine phosphate was ineffective. A standard anaesthetic technique was used: no premedication, thiopentone 6 mg/kg, fentanyl 100 μg, vecuronium 70 μg/kg, tracheal intubation, ventilation of the lungs with 30% oxygen in nitrous oxide and 1–3% enflurane, and reversal of neuromuscular blockade with atropine 1.2 mg and neostigmine 2.5 mg. Filshie clips were used for sterilisation.

Twenty-four LS and 36 DL patients were assessed for postoperative pain by one observer who interviewed each patient before operation. A 10-point analogue scale for pain intensity (the Burford Pain Thermometer) was used. Pain intensity was assessed at 0.5, 1, 2, 3 and 4 hours after the time at which the patient could give her date of birth. Postoperative analgesia was given on demand as usual, and patients were reassessed as soon as they requested pain relief.

We found that the LS patients had significantly more pain in the first 4 hours after surgery than the DL patients ($p < 0.02$ using the Mann–Whitney *U* test, which corrects for the difference in group sizes, Fig. 1). Pain intensity was the same in both groups at the time of administering codeine phosphate but, half-an-hour later, pain intensity was significantly greater in the LS group than in the DL group, and remained so for the next 3 hours ($p < 0.05$, Fig. 2).

Each patient was given a pain diary and a questionnaire to be kept for 2 days after operation. Seventy-seven percent of DL and 58% of LS patients returned completed questionnaires. These showed no significant difference ($p > 0.1$) in pain scores by the time of arrival home, or at any time during the following 2 days. Twenty-five percent of each group still needed analgesics on the second postoperative day.

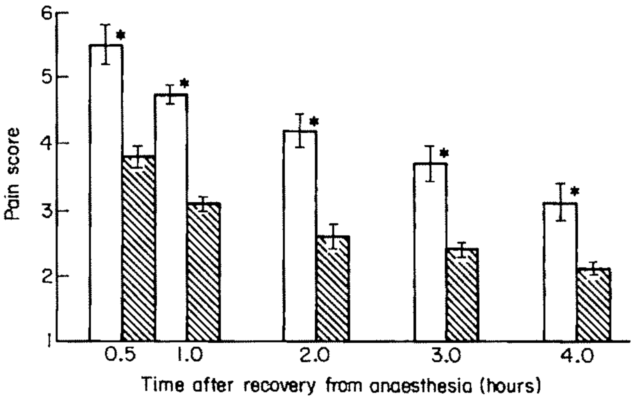

Fig. 1. Pain cores (mean, SEM) of all laparoscopy patients in the first 4 hours after operation. ■, diagnostic laparoscopy ($n = 36$); □, laparoscopic sterilisation ($n = 24$). * $p < 0.02$.

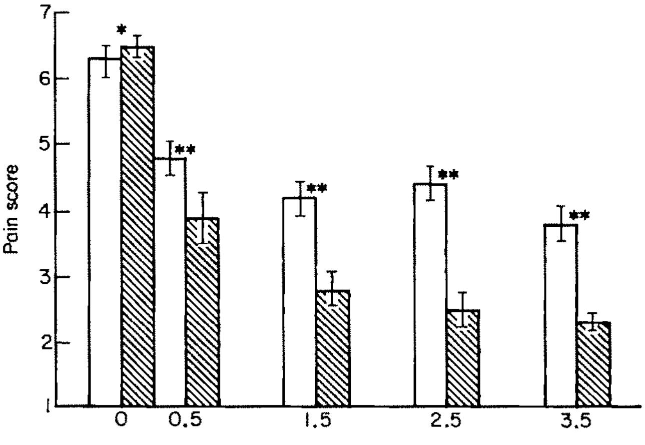

Fig. 2. Pain cores (mean, SEM) of laparoscopy patients who received codeine phosphate 60 mg. ■, diagnostic laparoscopy ($n = 18$); □, laparoscopic sterilisation ($n = 19$). * $p > 0.1$; ** $p < 0.05$.

This study showed firstly, that pain scores were initially higher in LS patients; secondly, that intramuscular codeine phosphate 60 mg was effective after DL but not after LS; and thirdly, that by the time of arrival home that evening there was no significant difference between the groups. It is reassuring to find that although LS patients do have more pain in the immediate postoperative period, their subsequent course shows no grounds for a change in the current practice of day cases. LS patients returned fewer pain diaries and questionnaires presumably because of domestic commitments. Had they been dissatisfied, we assume that they would have taken this opportunity to voice their complaints. The majority were satisfied.

We conclude that laparoscopic sterilisation is suitable for daycase surgery but requires more powerful postoperative analgesia than diagnostic laparoscopy, and that more research is needed to establish which parenteral analgesics provide good pain relief without delayed recovery.

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References

1. Collins KM, Docherty PW, Plantevin OM. Postoperative morbidity following gynaecological outpatient laparoscopy. A reappraisal of the service. *Anaesthesia* 1984; **39:** 819–22.
2. Goold JE. Anaesthesia for day-care surgery: a review. *Journal of the Royal Society of Medicine* 1983; **76:** 415–20.

Esmolol in the uncontrolled hypertensive patient

Esmolol, a new ultrashort-acting beta-adrenoreceptor blocker has been researched extensively under controlled clinical conditions,[1–4] but this is a report of its use during emergency surgery to manage a patient with uncontrolled hypertension.

The patient, who presented for emergency vitrectomy was a 51-year-old, 67 kg man with diabetes and hypertension which was controlled usually with clonidine 0.2 mg twice a day and nifedipine 10 mg three times a day. However, he had not taken any medication for 24 hours as a result of his acute eye discomfort and nausea. His blood pressure, on arrival in the operating theatre was 220/120 mmHg and his pulse rate 86 beats/minute. If surgery were to be postponed his eye would be endangered so immediate steps were taken to control the hypertension. The patient was in severe pain and a dose of droperidol 2.5 mg and alfentanil 1 mg was given to alleviate this and control hypertension. The diastolic pressure decreased to 95 mmHg but the systolic hypertension remained high. Two boluses each of 20 mg hydralazine were given 5 minutes apart and the patient observed for 25 minutes for signs of improvement. The systolic hypertension persisted.

Direct arterial monitoring was established during this observation period. A loading dose of esmolol (500 μg/kg over one minute) reduced the blood pressure to 105/60 mmHg. This relative hypotension could be attributed to beta-adrenoreceptor blockade superimposed on an alpha blocked and vasodilated patient. The blood pressure was allowed to increase over the next 2 minutes before a maintenance infusion of esmolol was administered. Anaesthesia was induced with thiopentone 4 mg/kg when the patient's blood pressure stabilised at 130 mmHg systolic. Intubation was facilitated with atracurium 0.6 mg/kg. The patient's systolic pressure increased to a 145 mmHg peak during laryngoscopy but levelled to 125 mmHg during maintenance of anaesthesia. Pulse rate remained at 60 beats/minute during the intraoperative period. The esmolol infusion rate was decreased to 10 μg/kg/minute until 5 minutes before the end of surgery and then the infusion rate was increased to 50 μg/kg/minute to ablate any cardiovascular response to extubation.

The advantage of a betablocker with an elimination half-life of 9 minutes is that adjustments can be made to the plasma level very quickly to produce a therapeutic beta-adrenoreceptor blockade. This is critical in ischaemic heart disease[4–8] and hypertension. This antihypertensive response to esmolol was titrated easily against the infusion rate and provided good control of perioperative blood pressure. Esmolol provides a valuable approach to techniques of management of the uncontrolled hypertensive patient presenting for emergency surgery.

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References

1. Menkhaus PG, Reves JG, Alvis JM, Kirklin JK, Zorn GL, Karp RB, Pacifico AD, McGiffin DC, Govier AV, Henling CE, Lell WA, Samuelson PN, Harris CK. Attenuation of heart rate response to intubation by a new beta-adrenergic blocking drug, esmolol. *Anesthesiology* 1984; **61:** A20.
2. Ebert J, Gelman S, Coverman S, Gold M, Anderson W, Brindle F, Bell V, Sandage BW. Effect of esmolol on the heart rate and blood pressure response during endotracheal intubation. *Anesthesiology* 1985; **63:** A63.
3. Cucchiara RF, Benefiel DJ, Matteo RS, DeWood M, Albin MS. Evaulation of esmolol in controlling increases in heart rate and blood pressure during endotracheal intubation in patients undergoing carotid endarterectomy. *Anesthesiology* 1986; **65:** 528–31.
4. Reves JG, Flezzani P. Perioperative use of esmolol. *American Journal of Cardiology* 1985; **56:** 57F–62F.
5. Goldman L, Caldera DL. Risks of general anesthesia and elective operation in the hypertensive patient. *Anesthesiology* 1979; **50:** 285–92.
6. Prys-Roberts C. Anaesthesia and hypertension. *British Journal of Anaesthesia* 1984; **56:** 711–24.
7. Prys-Roberts C, Meloche R. Management of anesthesia in patients with hypertension and ischemic heart disease. *International Anesthesiology Clinics* 1980; **18**(4): 181–217.
8. Magnusson J. Werner O, Carlsson C, Nordén N, Pettersson KI. Metoprolol, fentanyl and stress responses to microlaryngoscopy. *British Journal of Anaesthesia* 1983; **56:** 405–14.

Prolonged bradycardia and hypotension after neostigmine administration in a patient receiving atenolol

The case report by Eldor *et al.* (*Anaesthesia* 1987; **42:** 1294–7) is interesting. They emphasise the need to exercise caution when patients who are on long-acting β-blocker therapy are anaesthetised, but may we be permitted to comment on the recommendation made by them at the end of the report. The statement made by the authors that it is not justifiable to substitute long-acting β-blockers with short-acting ones for short surgical procedures is of concern for three reasons. Firstly, as stated by the authors, there has been less overall anaesthetic experience with patients on longer-acting β-blockers than those receiving propranolol. Secondly, long-acting β-blockers, especially nadolol, produce intense bradycardia resistant to atropine; unlike that associated with propranolol the bradycardia is usually responsive to atropine (Professor C. Prys-Roberts, lecture on 'Anaesthetic considerations for the patient with hypertension' to American Society of Anaesthesiologists in Las Vegas, 1986).

Our observations have been similar in quite a few patients on nadolol. A 50-year-old woman was admitted into our hospital electively for abdominoperineal resection of rectum. There was nothing significant in her past medical history except that she was receiving 120 mg/day of nadolol for control of hypertension. Her pulse rate was 72/minute, blood pressure 140/90 mmHg and the ECG was normal before operation. She received morphine 10 mg as premedication one hour prior to induction. She did not receive any β-blockers on the day of surgery. Anaesthesia was induced with 250 mg thiopentone and suxamethonium 90 mg (1.5 mg/kg) to facilitate tracheal intubation. The blood pressure was 90/60 mmHg after induction but the heart rate decreased to 38 beats/minute (sinus bradycardia). There was no response to two doses of atropine of 0.6 mg each. Pancuronium 6 mg did not increase the heart rate. The surgery was postponed in view of the bradycardia and the patient's lungs were ventilated in the intensive care unit until the effect of pancuronium wore off. Neostigmine was not used for the fear of aggravating bradycardia. The heart rate gradually increased to 72 beats/minute in next 6 hours.

Subsequently nadolol was changed to propranolol (120 mg/day in divided doses) and the patient underwent surgery uneventfully with the heart rate remaining within 72–78 beats/minute throughout the surgical procedure. It has been our practice since then to change from nadolol to propranolol 48 hours before elective surgery in view of the long half-life of nadolol (20–24 hours) compared to propranolol (2–4 hours). Finally, as the authors point out, since bradycardia and hypotension in patients who receive longer-acting β-blockers are both refractory and prolonged the recovery phase would be expected to be shorter in a patient on short-acting β-blockers. Further, in keeping with our general trend to choose shorter-acting drugs during anaesthesia propranolol may be preferred to longer acting β-blockers.

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A reply

We would like to thank Drs Shankar, Moseley and Kumar for their interesting letter. Their case report of refractory bradycardia with nadolol and anesthesia, and similar anesthetic experiences with long-acting betablockers seem to be of clinical importance. In our original manuscript our recommendation was similar to their conclusion, that is substitution of long-acting betablockers with short-acting ones before elective surgery.

The reviewers of the article advised caution with such a decisive recommendation, stating: 'The conclusion that atenolol should be replaced by another drug on the basis of this exceptional case may not be justified'. Their advice led to the revision of our original conclusion, pending further clinical evidence. Dr Shankar *et al.*'s case report and their experience as stated in the letter, lends weight to our original recommendation. It is interesting to note that in their case report the patient demonstrated refractory bradycardia after premedication with morphine, and induction with thiopentone and suxamethonium. Is this an additional anaesthetic drug–betablocker interaction? If so, caution during induction must be practised even when short-acting betablockers have been administered.

In our report induction of anaesthesia also led to hypertension and bradycardia, but responded to atropine, ephedrine and fluid load. In both these cases suxamethonium or the narcotic seems to be the culprit, but pinpointing specific drug–drug reaction when many drugs are involved is to say the least, difficult.

The introduction of short-acting noncumulative muscle relaxants and routine neuromuscular junction monitoring means that neostigmine can and should be avoided in patients treated with betablockers, especially of the long-acting type.

A firm recommendation will have to await further information.

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Flushing between thiopentone and atracurium

A patient developed an inflammatory rash and wheezing on induction of anaesthesia. The advice of the Supraregional Protein Reference Unit was that the reaction was caused partly by a failure to flush the intravenous needle between thiopentone and atracurium, which resulted in 'aggregate anaphylaxis'.[1]

This is a report of a pilot study to examine whether flushing intravenous needles between thiopentone and atracurium affected the incidence of skin and chest reactions. The patients were fit women undergoing laparoscopy. Premedication was with oral temazepam and intravenous induction was with droperidol, fentanyl, thiopentone and atracurium. The patients were allocated randomly to two groups, in one of which the needle was flushed with saline between the last two drugs. Observations were made after intubation and at the end of the operation. Rashes were scored as 1 for a rash confined to the course of the vein used, 2 for one confined to the arm used for injection or 3 for a rash on the trunk. Chest auscultation was performed.

Three patients out of 41 in the nonflushed group (Group 1) developed rhonchi on intubation compared with one out of 33 in the other group. Rashes were more common in the nonflushed group, but the difference was not statistically significant (p greater than 0.1 using the Chi-squared test).

Table 1. Patient responses after atracurium with a flushed or nonflushed needle.

Cutaneous reaction score		(0)	(1)	(2)	(3)	Total
At induction	Group 1	22	10	5	4	41
	Group 2	23	4	3	3	33
At end of operation	Group 1	30	7	3	1	41
	Group 2	27	3	1	1	33

It can be seen in Table 1 that flushing before atracurium does not prevent the common skin reactions; indeed, previous studies in which the relaxant was given into a separate vein from the thiopentone or long afterwards still demonstrate such reactions in 20 to 63% of patients.[2,3] A larger study could possibly demonstrate that flushing does reduce the incidence of mild reactions or prevent severe ones: this would need very large numbers and would now probably be unethical in view of the authoritative advice on the subject.[1,4]

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References

1. Watkins J. Histamine release and atracurium. *British Journal of Anaesthesia* 1986; **58:** 19S–22S.
2. Nightingale DA, Bush GH. Atracurium in paediatric anaesthesia. *British Journal of Anaesthesia* 1983; **55:** 115S.
3. Mirakhur RK, Lavery GG. Local reactions and histamine release by atracurium, a reply. *Anaesthesia* 1985; **40:** 593–5.
4. Tracrium* Injection. *ABPI Data Sheet Compendium 1988–9.* London: Datapharm Publications, 1988: 329.

Flow directed pulmonary artery catheter obstructs venous drainage cannula of cardiopulmonary bypass machine

We use routinely pulmonary artery balloon flotation catheters for open heart surgery. Lack of flow through the pulmonary artery, catheter stiffening due to cooling, distal tip replacement, fixation in a superior vena caval snare, and manipulation of the heart, combined, all create a risk of perforation of the pulmonary artery.[1] It is therefore also our practice to withdraw the catheter into the proximal pulmonary artery before cardiopulmonary bypass. A catheter that 'wedges' spontaneously, with the flotation balloon deflated, should be withdrawn to prevent distal ischaemia and vessel damage by the catheter tip.

One of the purposes of the catheter is to monitor pulmonary artery pressure when the patient is weaned off cardiopulmonary bypass. The pulmonary artery diastolic pressure is then used to guide filling requirements. Precautionary withdrawal of the catheter may position the tip in the right ventricle or even in the right atrium, so we advance it (with caution), when there is some cardiac output, but before the end of cardiopulmonary bypass. We report two cases where the catheter was advanced accidentally into the venous cannula of the bypass system, with potentially life threatening results. The venous cannula in both cases was a two-stage 'polystan' cannula (Polystan, 36/52F, 'straight, hard'). The catheter is presumed to have passed through one of the proximal fenestrations, since the distal end is positioned in the inferior vena cava.

In the first case, a Criticath flotation catheter (Spectramed/Gould Inc., SP5107H, 7F) was used in an adult patient, through the right subclavian vein. Displacement of the catheter into the right ventricle occurred during the preparation of the left internal mammary artery. It was not possible to advance the catheter into the pulmonary artery again and in the effort the catheter was withdrawn into the right atrium. The catheter was advanced with inflated balloon before weaning the patient off cardiopulmonary bypass; after 8 cm a negative pressure was encountered, there was an impairment of venous return, and the surgeon noticed the catheter in the venous cannula. The balloon was deflated immediately and the catheter withdrawn. The patient was weaned from bypass with the aid of a left atrial catheter, and came to no harm.

The second case, which occurred 2 weeks later, involved an Edwards flotation catheter (Swan Ganz, Edwards, 93A-131H-7F) which was used in an adult patient by way of the right internal jugular vein, which required withdrawal several times because of spontaneous 'wedge' position (the pressure measured through the distal lumen exceeded 80 mmHg). Withdrawal freed the catheter and reduced this pressure. Re-advancing the catheter was attempted without inflation of the balloon at first; the user was aware of the first case. There were arterial pressure waves but the patient was still on full flow cardiopulmonary bypass. An attempt was made with the balloon (fully) inflated when a ventricular pressure wave was not found. The catheter was advanced 10 cm, and a negative pressure encountered, when the perfusionist noticed a rapid decrease in volume in the blood reservoir. The surgeon could see the balloon in the venous cannula, followed by distension of the right atrium. All was resolved immediately by deflation of the balloon, but the angle of entry made it impossible to withdraw the catheter from the cannula. The patient was weaned off cardiopulmonary bypass without the benefit of knowing the pulmonary artery pressures, and the venous cannula was removed. The catheter could then be withdrawn easily through the purse string into the right atrium, and was advanced successfully into the pulmonary artery. The patient suffered no ill-effect.

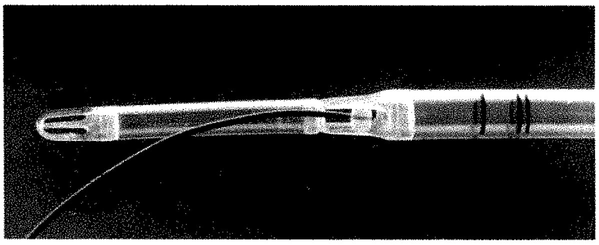

Fig. 1.

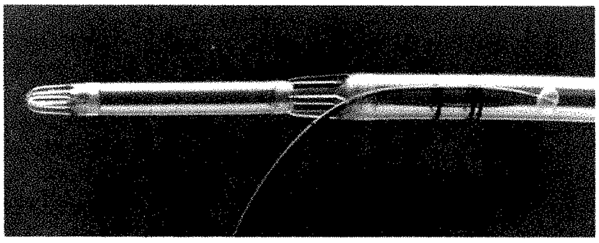

Fig. 2.

An inflated balloon does not pass (easily) through the proximal fenestration of this venous cannula (Fig. 1) but, once in the lumen it can obstruct flow almost completely (Fig. 2). It seems likely, therefore, that in our cases the catheter tip was already in the venous cannula when the balloon was inflated.

This complication has not been described before to our knowledge,[2–6] but was always a possibility. Its occurrence twice in quick succession in our unit, is striking. We urge extreme caution when advancing flotation catheters whilst flow out of the right atrium is bi-directional, and the catheter tip position is uncertain.

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References

1. Barash PG, Nardi D, Hammond G, Walker-Smith G, Capuano PA, Laks H, Kopriva CJ, Baue AE, Geha AS. Catheter-induced pulmonary artery perforation. Mechanisms, management, and modifications. *Journal of Thoracic and Cardiovascular Surgery* 1981; **82:** 5–12.
2. Whalley DG. Haemodynamic monitoring: pulmonary artery catheterization. *Canadian Anaesthetists' Society Journal* 1985; **32:** 299–305.
3. Orkin FK. Complications of extracorporeal circulation. In: Orkin FK, Cooperman LH eds, *Complications in anesthesiology.* Philadelphia: J.B. Lippincott, 1983: 590–612.
4. Shah KB, Rao TLK, Laughlin S, El-Etr AA. A review of pulmonary artery catheterization in 6,245 patients. *Anesthesiology* 1984; **61:** 271–5.
5. Katz JD, Cronau LH, Barash PG, Mandel SD. Pulmonary artery flow-guided catheters in the peri-operative period. *Journal of the American Medical Association* 1977; **237:** 2832–4.
6. Goldenheim PD, Kazemi H. Cardiopulmonary monitoring of critically ill patients. *New England Journal of Medicine* 1984; **311:** 776–80.

Computerised tomographic scan appearances after lumbar epidural

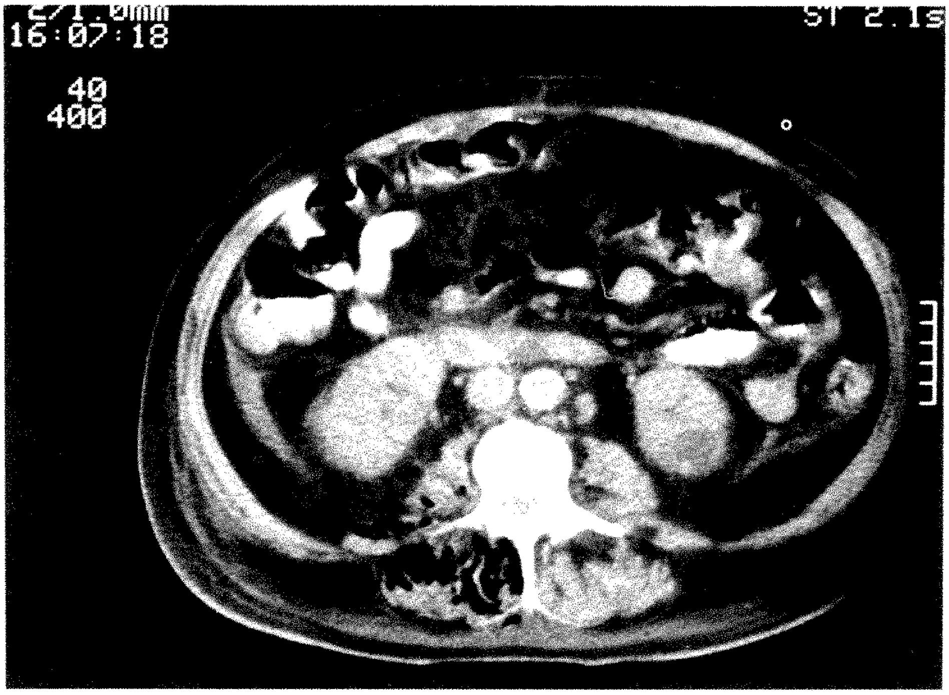

Fig. 1. Transverse CT section at L_3 level.

An obese 78-year-old man was admitted to Intensive Care for elective ventilation of his lungs after emergency repair of a perforated duodenal ulcer. His medical history included chronic obstructive airways disease with severe limitation of exercise tolerance. Attempts at weaning from ventilation were unsuccessful because of a functional ileus and persistent abdominal pain. A lumbar epidural was inserted at the $L_{3/4}$ interspace with considerable difficulty due to the size of the patient and inability to flex his spine. A loss of resistance to air technique was used and successful placement of a catheter occurred at the third attempt. Forty-eight hours later an acute septic event occurred. The epidural catheter was removed and a computerised tomographic (CT) scan performed to exclude an intra-abdominal abscess. The scan revealed the presence of gas in the erector spinae muscles which extended from L_1 to S_1 on the right, with retroperitoneal tracking that included the psoas sheath (Fig. 1). Repeat scan 2 days later showed almost complete resolution.

We are unaware of any previous reports of the presence of gas in this distribution after a loss of resistance to air technique. These incidental CT findings suggest that this complication may be a typical appearance in cases of difficulty.

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Epidural anaesthesia and instrumental delivery

The encouraging results shown by the paper (*Anaesthesia* 1988; **43:** 289–92) on continuous epidural infusion of 0.075% bupivacaine for pain relief in labour were interesting. However, I dispute the statement in the Discussion that 'there is an increased incidence of fetal malposition and instrumental delivery, up to 70% in primigravid patients, after epidural anaesthesia'. The first reference quoted leaves unanswered whether or not the second stage of labour was managed differently in the epidural and nonepidural groups. Evidence suggests that mothers with epidurals can be left in the second stage until the fetal head has descended and so avoid a forceps delivery, which may have been performed if the fetal head had not been allowed to descend.[1] Secondly, bupivacaine 0.5% was used and this causes more motor block and density of perineal analgesia than weaker solutions; both these factors would lead to an increased likelihood of forceps delivery.

The second paper quoted[2] quotes figures of 57% and 80% respectively for singleton vertex vaginal deliveries in patients who had epidurals as compared to all patients. However, the authors state that parity, obstetric and medical indications for epidurals have contributed to this difference even though these factors would not be enough to explain the difference alone. Furthermore, the epidurals in this paper were performed using 0.5% bupivacaine which may increase the forceps rate compared with weaker solutions as suggested above. Also although delay in expulsive efforts in the second stage was encouraged it was not practised uniformly.

Bailey and Howard[3] have published data which suggests that there is no increase in the forceps delivery rate after epidurals and it is interesting to note that they used 0.25% bupivacaine not 0.5% bupivacaine for 'uterine' pain (0.5% bupivacaine was used for perineal pain). They also latterly modified the management of the second stage to delay expulsive efforts.

In conclusion I suggest that there is no firm evidence that epidurals increase greatly the forceps rate and that the use of weaker solutions of local anaesthetic and delay of pushing until late in the second stage will help to prevent unnecessary intervention.

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F.E. Luscombe

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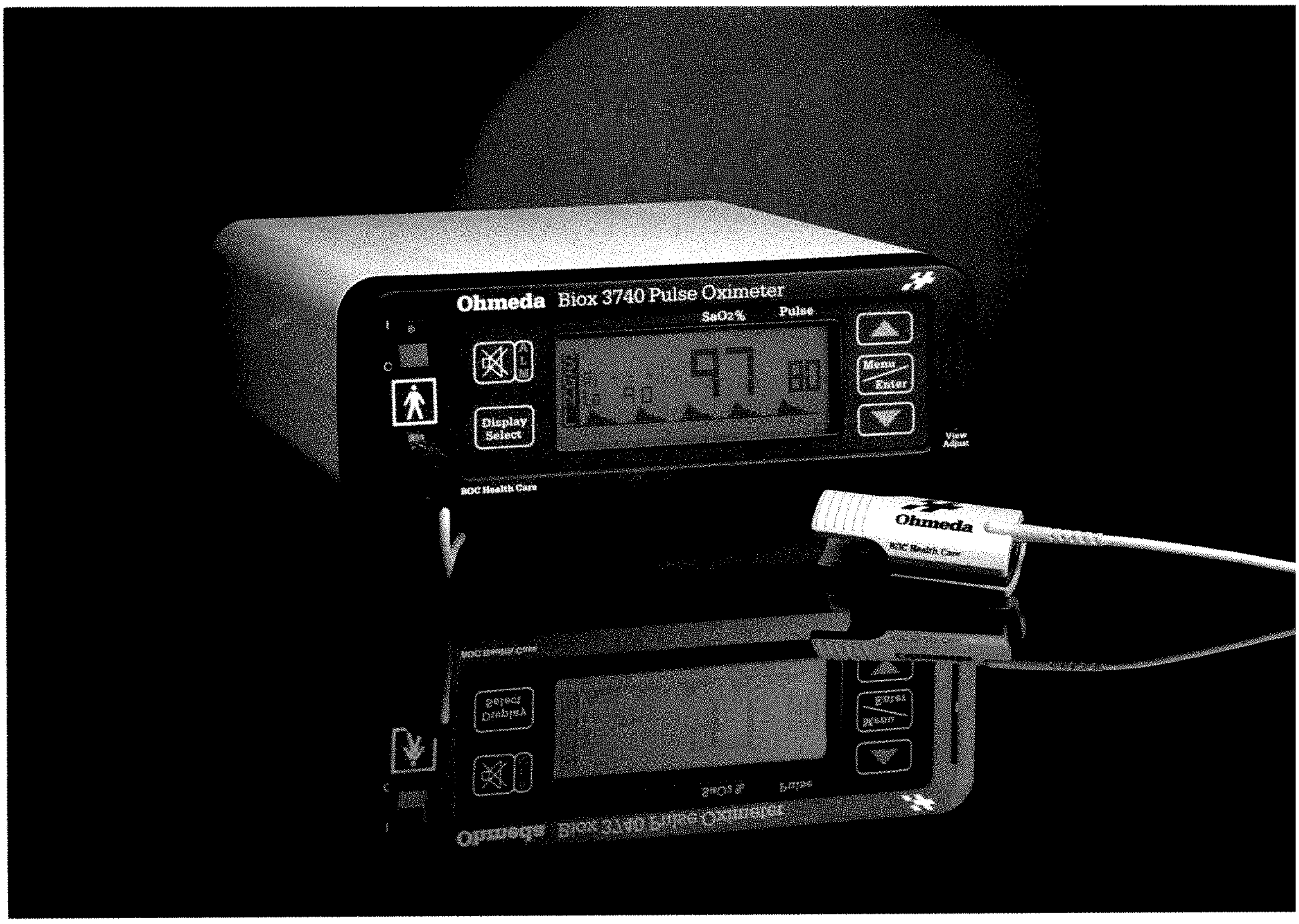

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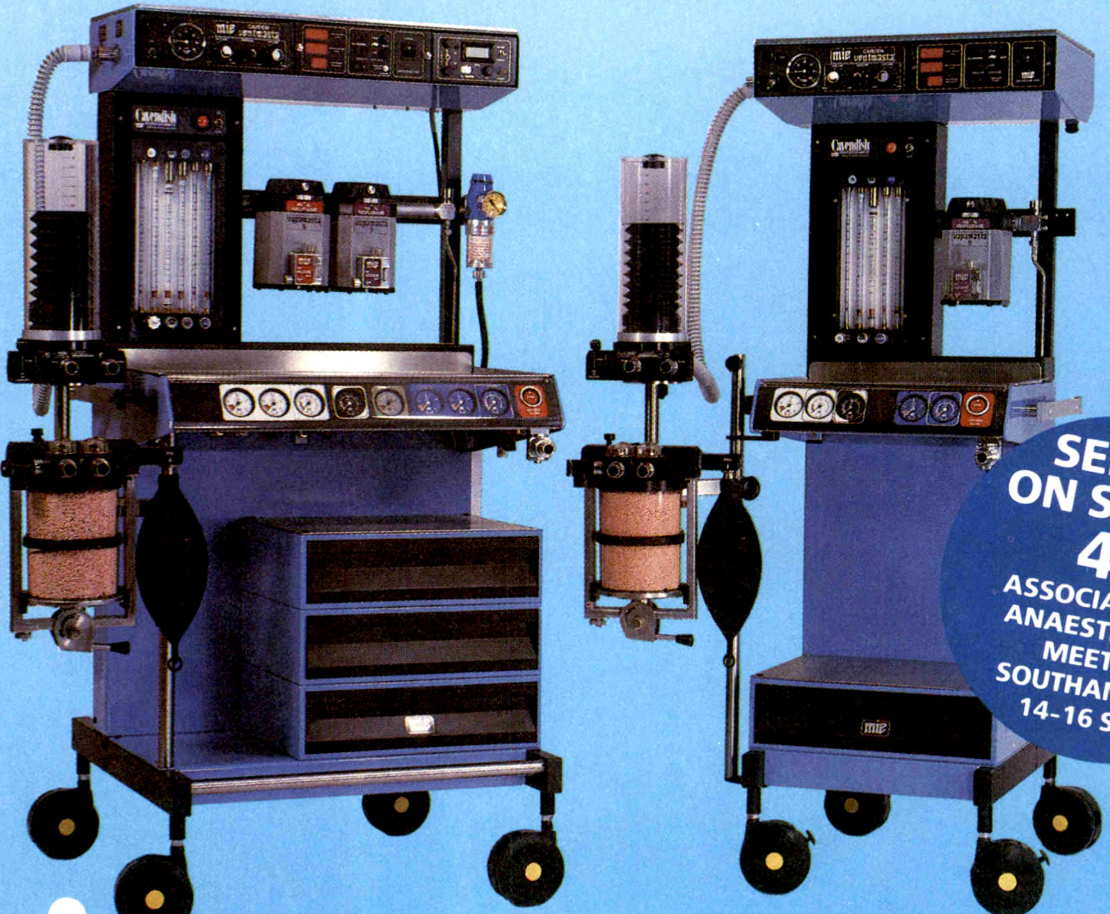

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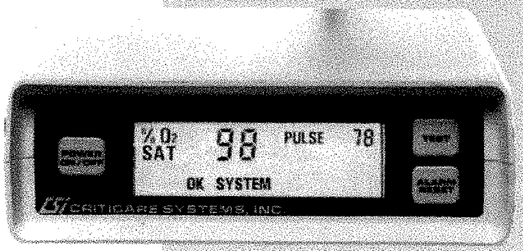

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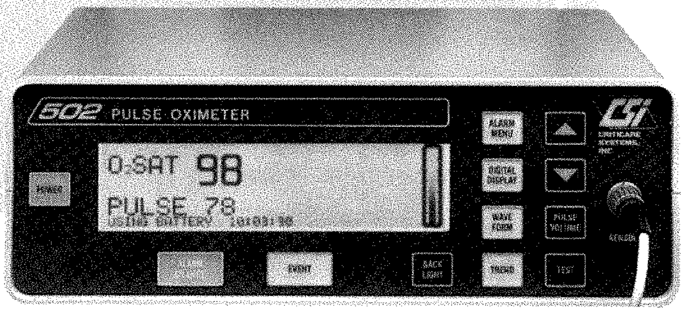

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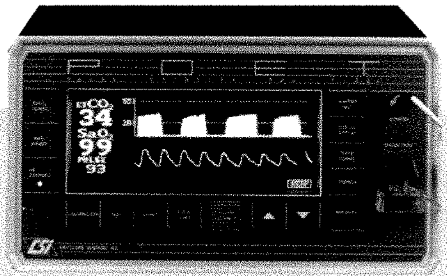

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References

1. Hoult IJ, MacLennan AH, Carrie LES. Lumbar epidural analgesia in labour: relation to fetal malposition and instrumental delivery. *British Medical Journal* 1977; **1:** 14–6.
2. Walton P, Reynolds F. Epidural analgesia and instrumental delivery. *Anaesthesia* 1984; **39:** 218–23.
3. Bailey PW, Howard FA. Epidural analgesia and forceps delivery: laying a bogey. *Anaesthesia* 1983; **38:** 282–5.

A reply

Thank you for the opportunity to reply to Dr Luscombe's letter, which, while not particularly relevant to our study, begs comment. Dr Luscombe suggests that the use of epidural analgesia in labour does not necessarily increase the instrumental delivery rate. Unfortunately, the study he quotes[1] was retrospective and used historical controls, which throws some doubt on the validity of its findings. We agree that improved management of the second stage of labour may decrease the need for intervention. However, Thorburn and Moir[2] have shown that both the volume and concentration of bupivacaine affect the instrumental delivery rate.

It is our experience that epidural analgesia increases the instrumental delivery rate. We believe the weight of evidence supports this view and that this is the view shared by the majority of obstetric anaesthetists.

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References

1. Bailey PW, Howard FA. Epidural analgesia and forceps delivery: laying a bogey. *Anaesthesia* 1983; **38:** 282–5.
2. Thorburn J, Moir DD. Extradural analgesia: the influence of volume and concentration of bupivacaine on the mode of delivery, analgesic efficacy and motor blockade. *British Journal of Anaesthesia* 1981; **53:** 933–9.

Management of a parturient with Klippel–Feil syndrome

We were interested to read the case report by Drs Daum and Jones (*Anaesthesia* 1988; **43:** 18–21) about fibreoptic tracheal intubation in a patient with Klippel–Feil syndrome who presented for elective surgery. We had cause recently to contemplate the potential problems of the parturient with this syndrome.

A 26-year-old primagravida with Klippel–Feil syndrome was presented to the anaesthetic department at the 34th week of an uneventful pregnancy. She had previously had two minor anaesthetics neither of which required tracheal intubation. Examination revealed a short stiff neck and small mouth. Radiography showed fusion of the cervical vertebrae and a normal lumbar spine. The patient thus fell into Type I in Feil's original classification.

There seemed to be several management options in view of the known difficulty in tracheal intubation in patients with this syndrome[1] and the additional hazards of obstetric anaesthesia. The patient could be allowed to go into labour spontaneously in the presence of an adequate pelvis and an uneventful pregnancy. An effective epidural could be established early in labour. The epidural block could be extended to allow Caesarean section in the event of operative delivery and if time permitted. Consideration could be given to spinal anaesthesia if insufficient time was available to extend the epidural (but see below). A failed intubation drill would have to be implemented if general anaesthesia was unavoidable and tracheal intubation proved impossible (and, as Drs Daum and Jones note, there is no place for fibreoptic intubation in the emergency situation).

Elective induction of labour may lead to delivery at an optimum time when suitably experienced staff are available and forewarned and avoid the possibility of the patient presenting in labour requiring immediate Caesarean section. Epidural analgesia would again be reasonable. A third option would be to perform an elective Caesarean section at term. This would allow unhurried management by experienced anaesthetic and obstetric staff during daylight hours and avoid the hazardous circumstances of difficult intubation in a patient with perhaps a full stomach presenting for emergency Caesarean section. Epidural or spinal anaesthesia would be the treatment of choice for elective Caesarean section. However, it could be argued that the rare occurrence of total spinal or massive subdural after epidural anaesthesia, or the unpredictable and sometimes extensive spread of spinal anaesthesia necessitating emergency tracheal intubation, would make general anaesthesia with awake fibreoptic tracheal intubation the method of choice. Epidural or spinal anaesthesia may be impossible in patients with Type III Klippel–Feil syndrome (that is, Type I or II with co-existing fusion of the lower thoracic or lumbar spine).

It was decided after considerable discussion between anaesthetists, obstetrician and the patient, to await the spontaneous onset of labour. The patient duly presented in labour at term. Ranitidine 150 mg orally 6-hourly was prescribed for antacid prophylaxis. An intravenous infusion was started and an epidural catheter inserted uneventfully at the $L_{2/3}$ interspace. An initial bolus dose of 8 ml 0.5% bupivacaine was given after a test dose. An infusion of 7–9 ml/hour of 0.25% bupivacaine was started 30 minutes later. Labour was accelerated by artificial rupture of the membranes and a syntocinon infusion. The epidural infusion was supplemented by two doses of 6 ml 0.5% bupivacaine. Analgesia for the second stage was provided by 9 ml 0.5% bupivacaine and was satisfactory throughout the 9 hour labour which included a Neville Barnes forceps delivery as a result of delay in the second stage.

The management of the parturient with Klippel–Feil syndrome is fraught with additional difficulties to those described by Drs Daum and Jones, in a patient presenting for elective surgery.

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Reference

1. Latto IP, Rosen M, eds. *Difficulties in tracheal intubation.* London: Balliere Tindall, 1985.

Paediatric intubation—retrograde or blind?

The retrograde catheter method was described originally for intubation of the tumour-obstructed larynx[1] but the actual need, for this purpose or any other reported intubations, seems doubtful. Certainly someone with the ability of an anaesthetist is not required to perform it. It was used successfully by Cooper and Murray-Wilson (*Anaesthesia* 1987; **42:** 1197–200) in a 4.8 kg child, but the technique must surely be regarded as more invasive and less safe than others, with greater potential for possible complications because of the smaller paediatric airway.

Blind tracheal intubation may be attempted widely or practised in the paediatric age group but there seems little to indicate this in the literature. Yet, just as for adults, there is a need for anaesthetists to use every opportunity to acquire the skills necessary to cope with the intubation problems that can present. Practice on children with normal anatomy is invaluable for cases where the mouth does not open or the larynx cannot be visualised, and the intubation can sometimes prove more 'difficult' in the former.

Brechner[2] reported taking 45 minutes for blind nasotracheal in a neonate, with rhabdomyosarcoma of the tongue; this demonstrates that trauma need not accompany even prolonged attempts at intubation and that the intubator should not give up too easily if there is no difficulty in maintaining the airway. There are several means, contrary to the view expressed by Cooper and Murray-Wilson, whereby fibreoptic laryngoscopes can be used to intubate with smaller than 4.0–4.5 mm tubes.[3–5] I resort to the widely available ordinary malleable metal paediatric stylet or introducer to form the tracheal tube into the requisite shape when I experience difficulty in intubation. I have performed blind nasal intubation in a child (7.3 kg) without a stylet and in some children of less than 4 kg with the assistance of a stylet within the tube.

It is necessary to ask Cooper and Murray-Wilson which type of blind oral intubation they employed and to which they refer. Did they, for example, utilise a laryngoscope and try to insert the tube on an introducer or with Magill's forceps? If so, should this be referred to as 'blind oral intubation' since it will be confused with the nonlaryngoscopic methods like the divided airway,[6] the tactile fingers in pharynx, with/without introducer,[7] and the Welch chin-lift?[8] The head can be managed with the left hand and the tube manipulated on an introducer with the right. Blind orotracheal intubation has been done in this way in 28 children who weighed less than 15 kg, with a lowest weight of 4.8 kg, but my preference in small children is the nasal approach.

Incidentally, as with Pierre Robin syndrome, and some others with micrognathia, the extended head–neck position may possibly impair the airway and prevent intubation whereas flexion relaxes the tissues and can result in success. This could also have been a factor in the difficulty experienced by Cooper and Murray-Wilson.

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References

1. Butler FS, Cirillo AA. Retrograde tracheal intubation. *Anesthesia and Analgesia* 1960; **39:** 333–8.
2. Brechner VL. Unusual problems in the management of airways. I. Flexion-extension mobility of the cervical vertebrae. *Anesthesia and Analgesia* 1968; **47:** 362–73.
3. Stiles CM. A flexible fiberoptic bronchoscope for endotracheal intubation of infants. *Anesthesia and Analgesia* 1974; **53:** 1017–9.
4. Alfery DD, Ward CF, Harwood IR, Mannino FL. Airway management for a neonate with congenital fusion of the jaws. *Anesthesiology* 1979; **51:** 340–2.
5. Laravuso RB, Perloff WH. Difficult pediatric intubation. *Anesthesiology* 1986; **64:** 668.
6. Berman RA. A method for blind oral intubation of the trachea or esophagus. *Anesthesia and Analgesia* 1977; **56:** 866–7.
7. Hudon F. Intubation without laryngoscopy. *Anesthesiology* 1945; **6:** 476–82.
8. Haisch CE. Respiratory management of the surgical patient. In: Dudley H, Pories WJ, eds. *Rob and Smith's operative surgery*, 4th edn. London: Butterworths, 1982: 12–26.

A reply

Thank you for the opportunity to reply to Dr Williamson's letter which seems to make five points.

He implies that there is never an indication for retrograde intubation in any age group. We disagree strongly with this inadequately-supported statement. The technique is supported by the references of the original article. We agree that fibreoptic laryngoscopy can be used to assist intubation with tubes smaller than 4.5 mm, but skill is required. Unfortunately, although it approaches, the day when the instrument is available everywhere and all anaesthetists are familiar with its use, has not arrived.

Dr Williamson recommends that we should practice various techniques for difficult intubation on normal patients. Currently the ethics of learning fibreoptic (usually nasal) intubation in adults with normal airways are being debated in our local hospitals. Majority opinion appears to be that this is acceptable only when the patient would have been customarily intubated by this route. Practising blind techniques may be acceptable in adults as long as the attempt is abandoned if difficulties arise. We do not feel it justifiable to adopt this practice in small infants. Anaesthetists should seize every *legitimate* opportunity to extend their repertoire of intubation techniques for use in the event of difficulties. We would like to state that we did attempt the blind techniques suggested by Dr Williamson apart from the digital insertion he recommends. We even used simultaneously two laryngoscope blades; the mouth would not admit two fingers. We did not list these techniques as our aim was to discuss retrograde intubation. Neck flexion can be a useful technique to aid visualisation of the larynx in difficult cases and may aid the passage of a nasal tube that is catching at the glottis against the anterior wall. It was of no avail in our case.

Retrograde intubation is invasive. It is also effective. For this reason we stated that 'it should be considered when difficult intubation is expected, but attempted only after conventional intubation has failed and tracheostomy is not specifically advantageous to the patient'. Conventional intubation in the context of the case report implies inclusion of blind techniques from above the larynx. The increasing availability of the fibreoptic laryngoscope may now warrant its inclusion in the term conventional.

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Patient-controlled analgesia

We would like to comment upon the recent report by Clyburn and Rosen (*Anaesthesia* 1988; **43:** 190–3).

It is of particular interest that in a two-group investigation of patient-controlled analgesia similar amounts of pethidine were administered to produce pain relief, but that the perception of the analgesic quality was diminished in the group who received the pethidine and doxapram combination. We agree with their overall assessment that the combination of pethidine and doxapram in this study failed to show any advantage over pethidine alone. However, we believe that a possible explanation for this finding may be provided by an examination of the biotransformation of pethidine.

The two main metabolic pathways for pethidine are either hydrolysis to pethidinic acid or N-demethylation to nor-pethidine and subsequent hydrolysis to nor-pethidinic acid. Nor-pethidine is the only metabolite to exhibit significant pharmacological activity. Nor-pethidine has a plasma half-life of 14–21 hours compared to the 4–6 hour half-life of pethidine. Consequently repeated doses of pethidine will lead to an accumulation of nor-pethidine.[1] This effect is accentuated in patients with impaired renal function where the half-life of nor-pethidine is prolonged beyond 21 hours.[2]

Pethidine is a neurorespiratory depressant, but nor-pethidine is a stimulant and is known to have epileptogenic effects on the central nervous system, and causes symptoms of shakiness, tremors, twitching, multifocal myoclonus and even grand mal seizures.[3] The toxic effects of accumulation of nor-pethidine predominate when the nor-pethidine: pethidine ratio increases above unity; the recommended maximum dose of pethidine in a 24-hour period is for this reason 250 mg.[4]

The pethidine-only group received 405 mg (range 210–630 mg) in this study compared to the combination group who received 420 mg (range 120–750 mg) in a 24-hour period. The combination of another central nervous system stimulant doxapram, in the study, in the presence of increasing concentrations of nor-pethidine is a possible reason for the poor quality of analgesia and is probably inadvisable.

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References

1. Szeto HH, Inturrisi CE. Simultaneous determination of meperidine and normeperidine in biofluids. *Journal of Chromatography* 1976; **125:** 503–10.
2. Szeto HH, Inturrisi CE, Hourde R, Saal S, Cheigh J, Reidenberg MM. Accumulation of normeperidine, an active metabolite of meperidine in patients with renal failure or cancer. *Anals of Internal Medicine* 1977; **86:** 738–41.
3. Miller RR, Jick H. Clinical effects of meperidine in hospitalized medical patients. *Journal of Clinical Pharmacology* 1978; **18:** 180–9.
4. Kaiko RF, Foley KM, Grabinski PY. Central nervous system excitatory effects of meperidine in cancer patients. *Annals of Neurology* 1983; **13:** 180–5.

An orotracheal tube with laryngeal hooks

Inadvertent bronchial intubation is one of the common problems associated with tracheal intubation. This may be the case particularly when conditions are adverse or the operator is inexperienced. A change in the design of tracheal tubes might help to avoid this pitfall.

The length of the human trachea varies from 4 cm in the neonate to 9–15 cm in the adult.[1] However, the distance from the upper end of the cuff on an adult-sized tracheal tube to the distal level is about 5 cm; this reduces the margin for error in a small person to only 4 cm.

A simple modification to the standard Magill pattern cuffed orotracheal tube is suggested to prevent bronchial intubation. Two lateral projections, at right angles to the long axis of the tube, are added to the tube wall at a distance 1–2 cm above the upper margin of the cuff. These laryngeal hooks, formed of the same Implant Tested material as the tube wall, are of a blunt, atraumatic nature and 1–1.5 cm in length (Fig. 1). Uncuffed paediatric tubes might also be modified to include similar laryngeal hooks.

The correct placement of a tracheal tube is ensured by careful observation. However, tube design may be used to influence positioning. The Cole pattern paediatric tube incorporates a shoulder to prevent over-deep placement.[2] One of the problems with the Cole design is laryngeal damage with prolonged intubation.[3] Carinal hooks have been used for the deliberate bronchial positioning of double lumen catheters.[4] Markers at the distal end of a tube may also be a valuable aid.

It is proposed that this simple modification to the Magill tracheal tube might prevent a common mishap without making intubation more difficult or traumatic.

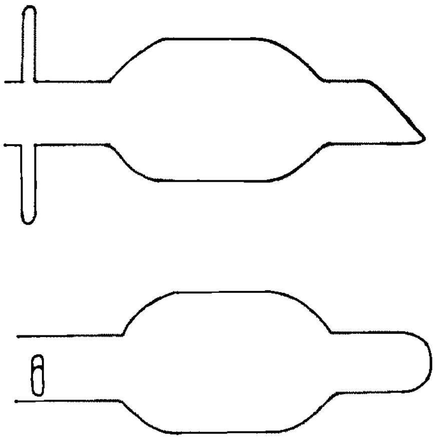

Fig. 1. Distal portion of tracheal tube displaying laryngeal hooks.

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A. Macneil

References

1. Engel S. *Lung structure.* Springfield, Illinois: CC Thomas, 1962.
2. Cole F. A new endotracheal tube for infants. *Anesthesiology* 1945; **6:** 87–8.
3. Brandstater B. Dilation of the larynx with Cole tubes. *Anesthesiology* 1969; **31:** 378–9.
4. Carlens E. A new flexible double-lumen catheter for bronchospirometry. *Journal of Thoracic Surgery* 1949; **18:** 742–6.

Cuff palpation does not differentiate oesophageal from tracheal placement of tracheal tubes

Recent correspondence about ways to confirm tracheal tube placement, included a test which depends on cuff palpation described as 'simple, rapid and reliable'.[1] The original article[2] assessed its ability to predict level of descent of the tracheal tube in the trachea rather than tracheal intubation as opposed to oesophageal intubation. Charters and Wilkinson in the same correspondence section questioned what happens with this test when the tracheal tube is misplaced in the oesophagus.

We studied 25 consecutive patients in the course of our normal duties where tracheal intubation was undertaken as part of their general anaesthesia. The trachea was intubated under direct vision without difficulty in all cases. After inflating the cuff of this tube, a second tube, the same length as the first, was placed in the oesophagus. A further 5 ml air was injected briskly into the tracheal tube, with the oesophageal tube still deflated, and the front of the neck palpated. This cuff was then returned to its previous state and 5 ml air injected into the oesophageal tube, again while palpating the front of the neck. Finally, the cuff of the tracheal tube was deflated completely and the oesophageal tube tested as before with 5 ml air.

It was possible to detect a response to the injection of air in all cases by palpation of the front of the neck. It made no obvious difference whether the tracheal tube cuff was inflated or otherwise, to what was felt when the oesophageal tube was inflated. A clear lateralised pulsation was found in 5/25 by which discrimination between the two tube locations would be possible. The only differences noted in the remaining cases was in 4/25 where the oesophageal test caused a more easily palpated pulsation, presumably because of the thinner wall of the oesophagus.

Cuff inflation may stop gas leaking round a tube placed in the oesophagus.[3] Stirt in 1982 reported a case where the cuff was considered to be palpable at the sternal notch but oesophageal misplacement was diagnosed subsequently.[4] The authors agree that cuff palpation is a good indicator of the level of descent of the tracheal tube and that it may be useful to avoid intubation of a mainstem bronchus. At the same time, the evidence presented suggests that it should be considered a poor test about the location of a tube.

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References

1. HIRSCH NP. Confirmation of tracheal tube placement. *Anaesthesia* 1988; **43:** 72.
2. EHRENWERTH J, NAGLE S, HIRSH H, LAMANTIA K. Is cuff palpation a useful tool for determining endotracheal tube position? *Anesthesiology* 1986; **65:** A137.
3. POLLARD BJ, JUNIUS F. Accidental intubation of the oesophagus. *Anaesthesia and Intensive Care* 1980; **8:** 183–6.
4. STIRT JA. Endotracheal tube misplacement. *Anaesthesia and Intensive Care* 1982; **10:** 274–6.

The oesophageal detector device

The maintenance of a subatmospheric pressure after aspiration with a 60-ml syringe, as described by Wee (*Anaesthesia* 1988; **43:** 27–9) appears to be a very reliable and refreshingly simple method for detection of oesophageal placement of a tracheal tube. The use of induction rooms in the United Kingdom often separates the anaesthetist from his capnograph at just the time when it is most useful.

Figure 1 shows an even simpler modification of Wee's technique comprising an Ellick's evacuator which is coupled directly to a tracheal tube connector. This can be assembled in a few minutes from materials to be found in any operating theatre and appears to have two special advantages: it can be used with one hand; the vacuum obtained is inherent in the properties of the evacuator and will be the same in all cases (9 kPa below atmospheric with an Ellick's evacuator).

The device in operation is connected to the tracheal tube and the bulb compressed. Compression is silent and refill is instantaneous if the tube is in the trachea. If it is in the oesophagus, compression is accompanied by a characteristic flatus-like noise and the bulb remains empty on release of pressure. The test can be accomplished easily within 3 seconds and the outcome is unmistakable.

Preliminary observations have shown very clear cut discrimination between tracheal and oesophageal placement in six patients and a trial is in progress to determine reliability in a larger series.

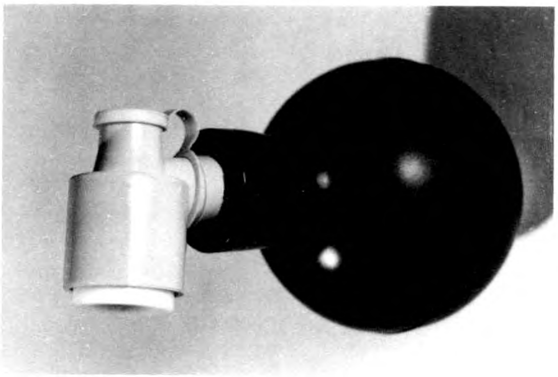

Fig. 1.

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Middlesex HA1 3UJ

J.F. NUNN

A complication of ilio-inguinal block

We thank Dr McNicol (*Anaesthesia* 1988; **43:** 706) for his interest in our brief communication and for confirming our supposition that the complication is hitherto unreported. It was, and continues to be, our intention to block both the iliohypogastric *and* ilio-inguinal nerves in our attempt to provide analgesia in these patients, and realise the extent of the sensory innervation which he outlines. The success of this is underlined by the fact that the patients described required no postoperative opioids. Our title was shortened for simplicity, but the error of this is now apparent.

Erickson's textbook states that needle insertion should be made two finger breadths (not cm as Dr McNicol asserts) medial to the anterior superior iliac spine, and that injection beneath the external oblique aponeurosis is made in a directly caudal or mediocaudal direction relative to the point of insertion.[1] Our technique employs injection at the point described: two finger breadths medial to the bony landmark, and inferiorly; but we avoid extension of the injection caudally by inserting the needle perpendicular to the skin and maintaining that position for injection beneath the external oblique aponeurosis, and thereby avoid distal placement of the solution. It is unlikely therefore, that injection beneath the inguinal ligament had occurred in the way that Dr McNicol imagines. We (and colleagues) have employed this technique on countless other occasions in the past, and it was our observation of this unusual occurrence which prompted the original letter. We note in addition that Littlewood reiterates that injection should be made 2.5 cm medial and inferior to the bony landmark in order to block these nerves.[2] Nevertheless, Dr McNicol is

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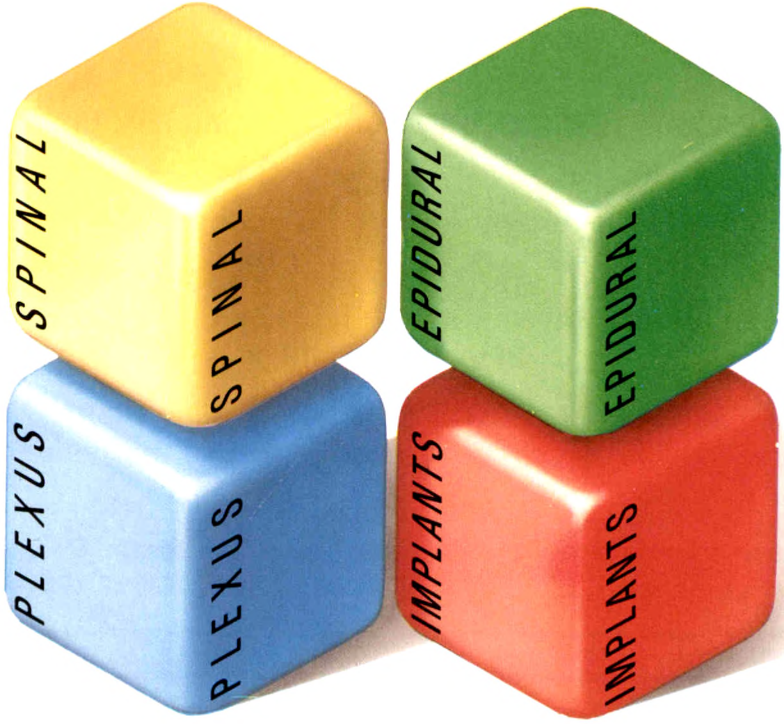

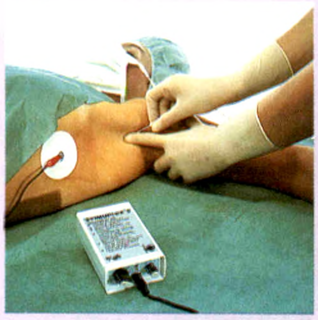

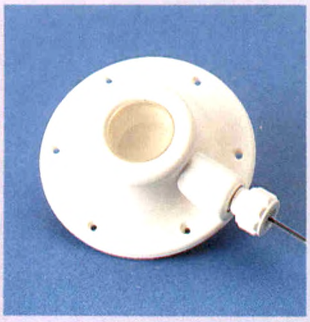

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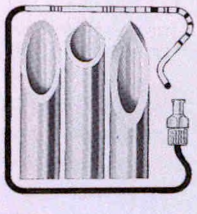

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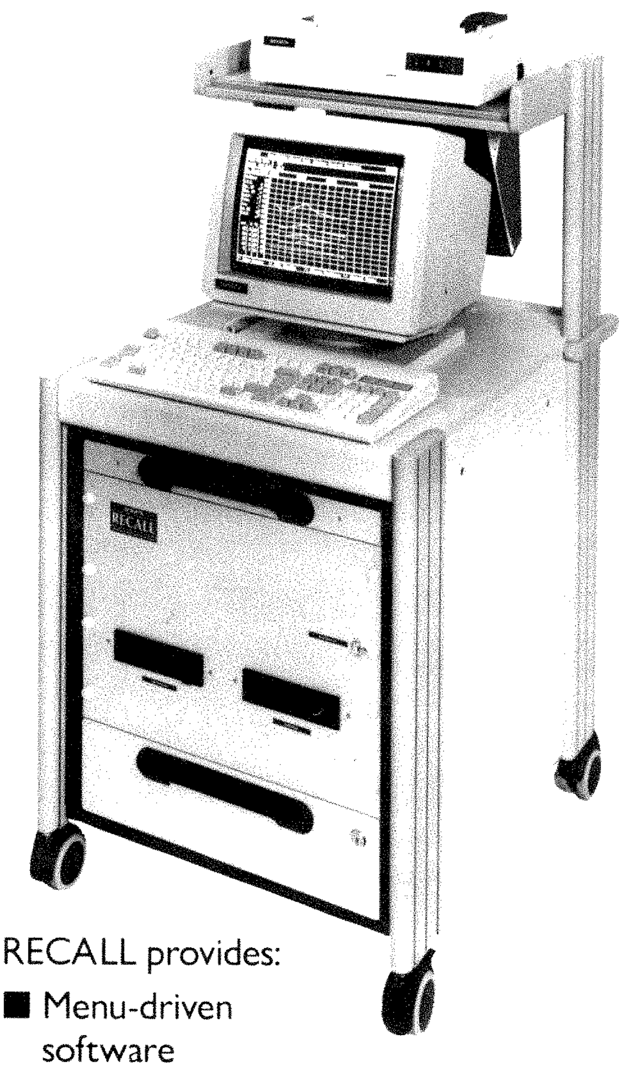

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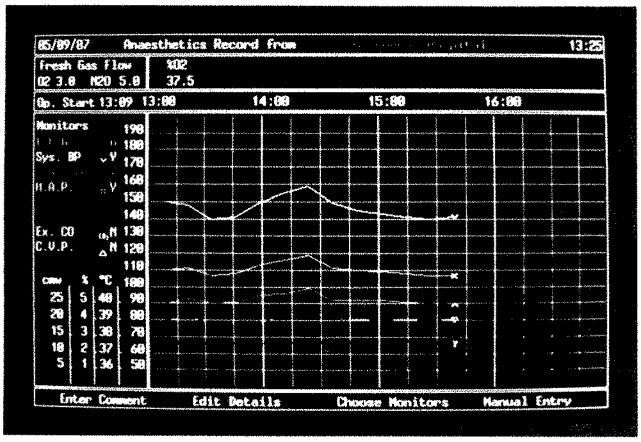

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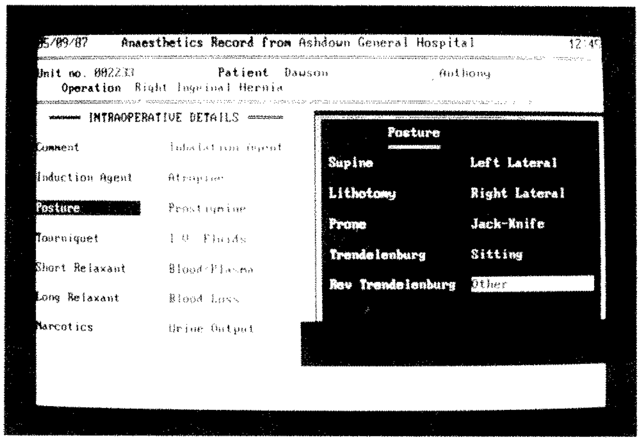
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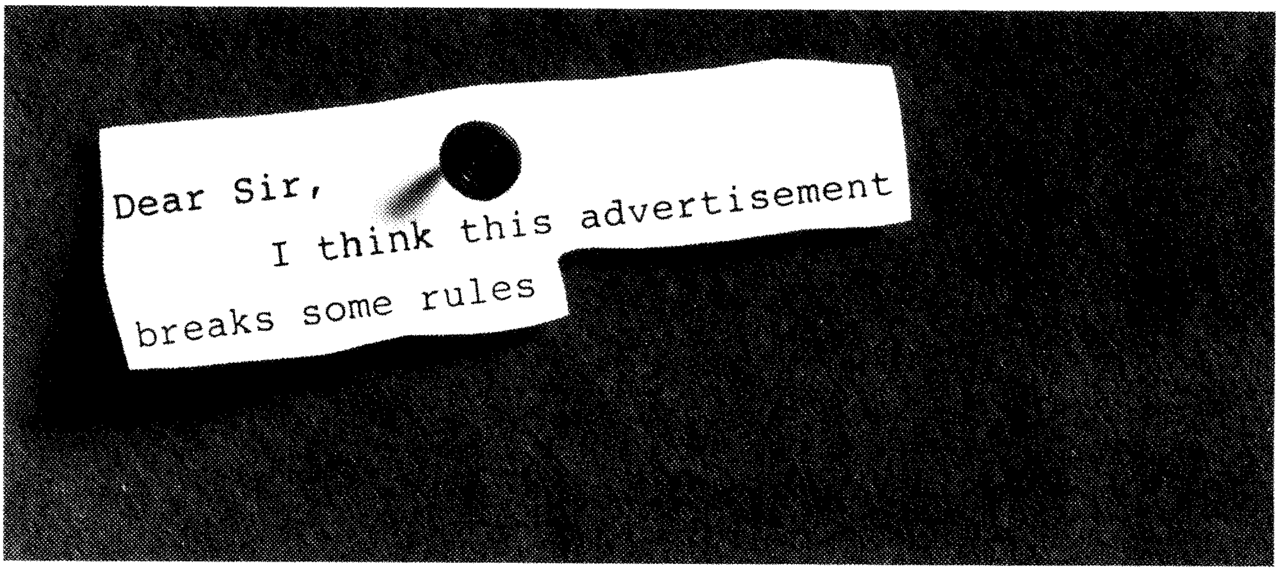

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correct to draw attention to the possibility in small patients, both adult and paediatric, of inadvertent misplacement of solution when using 'adult' landmarks.

We must differ, however, on the interpretation of Shandling and Steward's paper.[3] The block was indeed performed by the surgeon after preparation and draping; however, it is apparent from the statement 'the operation was then performed . . .' that it was inserted before surgery and before 'normal anatomical planes had been disrupted'.

Finally, we urge Dr McNicol to read our letter carefully, for at no time do we advocate that the patient be informed before operation of the possibility of this occurrence. Rather, we emphasise the need to forewarn nursing staff so that they can allay patients' anxiety in the event, and be aware of its transient existence.

Royal Hallamshire Hospital,
Sheffield R. LEWIS

Leicester Royal Infirmary,
Leicester D. FELL

References

1. ERIKSON E. *Illustrated handbook of local anaesthesia.* London: Lloyd-Luke, 1979.
2. LITTLEWOOD DG. Regional anaesthesia of the trunk. In: WILDSMITH JAW, ARMITAGE EN, eds. *Principles and practice of regional anaesthesia.* Edinburgh: Churchill Livingstone, 1987: 127–37.
3. SHANDLING B, STEWARD DJ. Regional analgesia for post operative pain in paediatric outpatient surgery. *Journal of Pediatric Surgery* 1980; **15:** 477–80.

Femoral nerve block as a complication of ilio-inguinal nerve block

We read with interest the letter by Drs Lewis and Fell (*Anaesthesia* 1988; **43:** 249) that concerned inadvertent femoral nerve block after ilio-inguinal nerve block for inguinal hernia repair. We have recently had a similar problem in a patient who attended our Pain Relief clinic.

A 48-year-old woman presented to us with a 2-year history of pain in the left groin which started 3 weeks after an abdominal hysterectomy through a Pfannensteil incision. We attributed her symptoms to entrapment of the ilio-inguinal and iliohypogastric nerves. The left ilio-inguinal and iliohypogastric nerves were blocked by inserting a 22-G 3.8 cm regional block needle 2 cm medial and inferior to the anterior superior iliac spine. Eight millilitres of 0.5% plain bupivacaine with 40 mg depomedrone was injected immediately after penetration of the external oblique aponeurosis. This was effective for 48 hours. The block was repeated at weekly intervals for 6 weeks with 0.5% plain bupivacaine alone except for the fourth injection when 40 mg depomedrone was again added. The duration of analgesia after each injection increased until by the end of the treatment the patient was pain-free.

The patient complained after the second injection of 10 ml 0.5% plain bupivacaine that she had experienced weakness of her left leg with numbness to just below the knee which lasted for 12 hours. We ascribed this to spread of the local anaesthetic solution to involve the femoral nerve. We used 7.5 ml of the same solution for the third injection in an attempt to prevent this recurrence. This was successful; there was analgesia without involvement of the femoral nerve. Subsequent injections were made with 8 ml 0.5% plain bupivacaine.

We therefore concur with Drs Lewis and Fell that femoral nerve block is a complication of ilio-inguinal nerve block. We also agree with their exposition of the anatomy of the area which is well illustrated in Grant's Atlas.[1] However, we disagree with their conclusion that the only explanation of this complication is diffusion of local anaesthetic across fascial planes. It seems more likely that penetration of the fascia iliaca occurred with the needle, and subsequent injection of local anaesthetic was below this fascia where it is free to spread to the femoral nerve. It is recommended in a recent text on regional anaesthesia,[2] that contact with the ileum be sought with an 8-cm needle before injection of local anaesthetic. This can be achieved whilst inserting and removing the needle to ensure that the ilio-inguinal and iliohypogastric nerves are blocked, but it is even more likely that penetration of the fascia iliaca will result in femoral nerve block.

This block is often performed with the needle perpendicular to the skin and using a 8-cm spinal needle it is quite likely that Drs Lewis and Fell penetrated the fascia iliaca. We use 3.8-cm regional block needles and an oblique approach and direct the needle tip laterally. This gives a more definite 'click' on penetration of the fascial planes than the perpendicular approach. It is obviously possible to penetrate the deeper layers even with this approach.

When this block is used in daycase surgery or in outpatients attending Pain Relief clinics it is appropriate to warn patients of the possibility of transient femoral nerve block.

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References

1. ANDERSON JE. *Grant's atlas of anatomy*, 8th edn. Baltimore/London: Williams and Wilkins, 1983.
2. LITTLEWOOD DG. Regional anaesthesia of the trunk. In: WILDSMITH JAW, ARMITAGE EN, eds. Principles and practice of regional anaesthesia. Edinburgh: Churchill Livingstone, 1987: 127–37.

Generalised seizures after etomidate anaesthesia

Myoclonus and generalised seizures have been reported after prolonged etomidate infusion used in the treatment of delirium tremens and for sedation of patients in intensive care units.[1,2] We report a case of generalised seizures after short-term anaesthesia with etomidate.

A woman, aged 36 years, who weighed 67 kg, was admitted for legal abortion on an outpatient basis. Her medical history included two cases of uncomplicated cerebral convulsions during childhood, but no other history of seizures and no family history of epilepsy. Clinical examination, haemoglobin and urinanalysis were normal. The patient received pethidine 75 mg and atropine 0.5 mg intramuscularly as premedication one hour before surgery.

Anaesthesia was induced with etomidate 20 mg (300 μg/kg) and maintained with doses of 16 mg (230 μg/kg) and 4 mg (50 μg/kg). Surgery lasted for 10 minutes. The patient's lungs were ventilated with 100% oxygen at a flow of 10 litres/minute through a rebreathing system and a facemask. Ventilation was adequate and blood pressure and heart rate remained stable during the event (120/80 mmHg, 80–100 beats/minute). Three minutes during recovery from the last supplementary dose of etomidate, the patient suddenly developed severe and generalised clonic convulsive movements and maximally dilated, but light-reactive, pupils. The duration of the seizures was 10 minutes and they were terminated by intravenous diazepam 15 mg in divided doses. The patient was unconscious during the event; ventilation was adequate, and blood pressure and heart rate were unaltered. The patient became responsive shortly after the seizures and recovery from anaesthesia was otherwise uneventful. Neurological examination after recovery revealed no abnormalities. An electroencephalograph recorded 14 days after the event was normal.

Animal experiments have shown that etomidate has a depressant effect on the reticular formation whereas the effect on the spinal cord seems to be facilitative or dysinhibitory.[3] Presumably, myoclonia is caused partly by activation at the spinal level and partly by reduced supraspinal control of afferent somatosensory impulses.[4]

Generalised seizures after short-term etomidate anaesthesia have been reported, however other drugs than etomidate have been held responsible for the development of seizures.[5] It can with reasonable certainty be assumed that etomidate has an ability to allow generalised seizures in a patient without demonstrable epilepsy, since etomidate was the only anaesthetic used during the operation and the operation ceased immediately before the seizures occurred. The apparent epileptogenic property of etomidate indicates that care should be exercised in the use of etomidate in epileptics.

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N.E. Drenck

References

1. Grant IS, Hutchison G. Epileptiform seizures during prolonged etomidate sedation. *Lancet* 1983; **ii:** 511–2.
2. Nickel B, Schmickaly R. Increased tendency to seizures under long-term infusions of etomidate in delirium tremens. *Anaesthesist* 1985; **34:** 462–9.
3. Baiker-Heberlein M, Kenins P, Kikillus H, Meinck H-M, Schomburg ED. Investigations on the site of the central nervous action of the short-acting hypnotic agent R-(+)-ethyl-1-(α-methyl-benzyl) imidazole-5-carboxylate (etomidate) in cats. *Anaesthesist* 1979; **28:** 78–84.
4. Meinck H-M, Möhlenhof O, Kettler D. Neurophysiological effects of etomidate, a new short-acting hypnotic. *Electroencephalography and Clinical Neurophysiology* 1980; **50:** 515–22.
5. Goroszeniuk T, Albin M, Jones RM. Generalized grand mal seizure after recovery from uncomplicated fentanyl-etomidate anesthesia. *Anesthesia and Analgesia* 1986; **65:** 979–81.

Anaemia and Jehovah's Witness

The case report by Howell and Bamber about their management of severe anaemia[1] was very interesting and they deserve congratulations. The letter by Dr Hasibeder *et al.* (*Anaesthesia* 1988; **43:** 255–6) merits comments. (The value of Hb described in the case report was 1.8 g/dlitre and not 1.8 g/litre.) They calculated the cardiac output to a value of 11 litres assuming oxygen consumption of 200 ml/minute according to Fick's law. Fick's law is inadequate for most clinical work nevertheless it remains the standard by which other methods are judged.[2] Their figure for cardiac output is also incorrect in the absence of data.

The percentage saturation of haemoglobin with oxygen depends largely on the tension of oxygen in the blood but the relationship is not linear and haemoglobin is 100% saturated when oxygen tension is 400 kPa.[3] On the other hand the amount of dissolved oxygen is directly proportional to the partial pressure no matter how high the $P\text{a}O_2$ rises.[3] The amount of dissolved oxygen is important because it is through this pathway that the oxygen passes to and from the haemoglobin and so reaches the tissues.[3] Oxygen capacity of haemoglobin is 1.39 ml/g when fully saturated and the dissolved oxygen in plasma is 0.0225 ml in 100 ml of whole blood/kPa applied oxygen tension.[4] In the case reported Hb was 1.8 g/dlitre and a mean $P\text{a}O_2$ of 31 kPa (26–36 kPa). The oxygen content of 100 ml arterial blood is approximately 3.19 ml if one assumes that haemoglobin was fully saturated at the above oxygen tension.

A minimum volume (200 × 100/3.19) of 6269.59 ml of blood is required to carry this amount if a minimum oxygen consumption of 200 ml/minute is assumed. In the absence of data about the other factors which affect the shape of the dissociation curve and haemoglobin saturation (except central venous oxygen tension 3.99 kPa), it is difficult to calculate the venous oxygen content and hence calculation of cardiac output is mere guesswork. The extraction of oxygen from arterial blood cannot be 100% and this was the case (venous oxygen tension was 3.99 kPa). An increase in cardiac output could be the answer but magnitude of increase would be a matter for speculation.

The fact of the matter is that the patient survived this anaemia; an increase in the cardiac output and the dissolved amount of oxygen played a major part.

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C.M. Kumar

References

1. Howell PJ, Bamber PA. Severe acute anaemia in a Jehovah's Witness. Survival without blood transfusion. *Anaesthesia* 1987; **42:** 44–8.
2. Sykes MK, Vickers MD, Hull CJ. *Principles of clinical measurement*, 5th edn. London: Blackwell Scientific Publications, 1981: 209.
3. Churchill-Davidson, HC. *A practice of anaesthesia*, 4th edn. London: Lloyd-Luke, 1979: 182–3.
4. Leigh JM. Oxygen Therapy. In: Scurr C, Feldman S, eds. *Scientific foundations of anaesthesia*, 3rd edn. London: William Heinemann Medical Books, 1982: 235–42.

Pruritus with sublingual buprenorphine

Pruritus has been reported as a side effect with intramuscular buprenorphine[1] but there are no reported cases of pruritus after sublingual administration.

A 65-year-old woman was seen in the Pain Clinic because she complained of ischaemic pain in her left foot; ischaemic pain in her other foot had been successfully treated with a lumbar sympathetic block. Minor analgesics had not controlled the pain and the patient was, therefore, started on buprenorphine. She complained that the buprenorphine caused severe itching, such that the drug could be used on only four occasions even though it controlled the pain well. The itching which started within 20 minutes of taking the buprenorphine and lasted generally about 4 or 5 hours, was mainly over the back and shoulders and was not associated with a rash. Other opiates (morphine and meptazinol) used to treat the pain did not have this effect. It is interesting to note that morphine controlled the pain, but that meptazinol did not.

Why opiates cause itching has never been explained completely although many causes have been postulated; since histamine causes itching, and many opiates cause histamine release, histamine was often presumed to be mediating this response. This theory has fallen into disrepute in recent years since nonhistamine releasing opiates cause pruritus,[2] and there is a high incidence of pruritus with spinal opiates,[3] and yet it is doubtful if histamine is present in the CSF. Antihistamines do not reduce opiate-induced itching.

The time course of this effect fits well with the known duration of action of buprenorphine,[4] and it is interesting to note that there was no tolerance to pruritus during the time that this patient was taking buprenorphine. No rash was seen and histamine release seems an unlikely cause of the pruritus in this case.

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London SE5 9RS

References

1. Wallenstein SL, Kaiko RF, Rogers AG, Houde RW. Crossover trials in clinical analgesic assays: studies of buprenorphine and morphine. *Pharmacotherapy* 1986; **6:** 228–35.
2. Bernstein JE, Grinzi RA. Butorphanol-induced pruritus antagonized by naloxone. *Journal of the American Academy of Dermatology* 1981; **5:** 227–8.
3. Scott PV, Bowen FE, Cartwright P, Mohan BC, Deeley D, Wotherspoon HG, Sumrein IMA. Intrathecal morphine as sole analgesic during labour. *British Medical Journal* 1980; **281:** 351–3.
4. Kay B. A double-blind comparison of morphine and buprenorphine in the prevention of pain after operation. *British Journal of Anaesthesia* 1978; **50:** 605–9.

Early textbooks on anaesthesia

Professor Secher (*Anaesthesia* 1985; **40:** 385–6 and 1987; **42:** 1022) has rendered a useful service to historians of our specialty by listing 38 books on the inhalation of ether which were published in 1847, and he surmised correctly that this list was not complete.

A further 18 similar publications are described in the first volume of Waring's bibliography[1] and these are listed below. Waring included only 23 of Professor Secher's titles, with some minor differences and two others which merit comment. Secher lists Bauer A. *de aethere sulphorico* while Waring attributes a lengthy title commencing *Uberschwefeläther* . . . to the same author for a 55-page work also published in Prague. Again, where Secher lists Chambert H. *des effets physiologiques produit par l'inhalation des different éthers* Waring says *des effets physiologiques et thérapeutiques des éthers* but states that this 260-page book was published in 1848. However, as will be described, the title as given by Waring was attributed to an 1847 work by Chambert.

Waring recorded usually the number of pages in each publication so I append a second list of some of Professor Secher's titles with this information and some notes on where the two bibliographies differ. Dr Richard Ellis[2] pointed out that not all the books on these lists are true textbooks, or as Professor Secher put it in agreeing with him 'they are not all books in the proper sense'; indeed so, pamphlet would be a more appropriate term for some and Waring so describes Robinson's pioneering work. Moreover some pamphlets may have been reprints from contemporary journals, and these caused considerable trouble for Waring who concluded that reprints '. . . promise to be a source of much greater trouble for future biographers.'

Professor Secher's speculation that the work by Brookes 'could have been earlier than Robinson's' is refuted by its content. For although Brookes' dedication is indeed dated in mid-February, the main text records cases in March, the latest on the 10th of that month. The work was in the author's words '. . . as much for the general as for the medical reader' and Waring reproduced a review of it from the *Med.-Chir Rev.* July 1847, p. 246—'Beyond a record of cases contains nothing new.'

The book by J.F. Lach on the other hand undoubtedly merits the appellation of textbook; this comprehensive work was completed in August and thus antedates the celebrated book by Snow, the only major authority whom he does not quote. Lach in his extensive bibliography mentions the books by Bergson, Dieffenbach, Heyfeld, Krasner, (de) Lavacherie, Rosenfeld and Siebold from those listed below; Dupuy, Robinson and Piragoff from Professor Secher's first list and many others as quotations from journals or from scientific meetings.

More importantly, in the context of this letter, Lach lists some further publications, though unfortunately he does not record their full descriptions: Pajot: *des Effets de l'inhalation des vapeurs d'éther*; Paris, 1847; F. et D.A.: *Appréciation de la propr. anaesthétique des vap. d'éther sulf.* Paris, 1847; Delabarre fils: *Guide du practien dans l'admin. des vapeurs d'éther.* Paris, 1847; Villeneuve: *De l'éthérisation appliquee à l'art des accouchements.* Marseille, 1847; Chambert: *des effets physiologiques et thérapeutiques des éthers.* Paris, 1847.

And from Italy: Une brochure remarquable de M. le professeur Porta, *Sur les inhalations éthériques au moyen de la vessie*, a été en grande partie traduite par les 'Annales de thérapeutique' (mai).

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References

1. Waring EJ. *Bibliotheca pharmaceutica.* (2 vols.) London: The New Sydenham Society, 1876: 107–9 and 123.
2. Ellis RH. Early textbooks on anaesthesia. *Anaesthesia* 1985; **40:** 386.

Additional 1847 publications in Waring[1]

Bauer A. *Ueber Schwefeläther und seine neueste Anwendung, mit einem Anahange über die in den offentlichen Anstalten Prags gewonnen Resultate.* Prague, 8vo. pp. 55.

Henot —. *Memoire sur l'Étherisation . . . et sur diverses opérations chirurgicales pratiquees sans douleur.* Metz, 8vo. pp. 53.

Jackson JBS. *Review of Dr M. Gay's statement as to Dr C.T. Jackson's claims to the discovery of the Inhalation of Sulphuric Ether as a preventive of pain.* Boston, US. 8vo.

Jeannel J. *Théorie de l'engourdissement et de l'insensibilité produits par les Inhalations Éthérées.* Bourdeaux, 8vo. pp. 8.

Lavacherie —. *Sur l'Inhalation de Vapeurs d'Éther pour supprimer la douleur dans les opérations chirurgicales.* Bruxelles, 8vo. pp. 50.

Longet, FA. *Expériences relatives aux effets de l'Inhalation de l'Éther Sulfrique sur le système nerveaux.* Paris, 8vo. (Described as 'a most elaborate and important memoir' in *Brit. and For. Med. Rev.*, April 1847, p. 570, where a summary of this author's observations is given).

Mortimer WH. *A Popular Essay on Anaesthetic agents for procuring painless operations . . . but especially in dental surgery.* London, 8vo. pp. 32. (Contains an examination of the relative merits of chloroform and ether, the question being settled in favour of the former.—*London Med. Gaz.*)

Morton W. *Mémoire sur la découverte du nouvel emploi de l'Éther Sulfrique.* Paris, 8vo.

Nathan E. *Ueber Aether-Rausch (Phrenopathia Aethera) mit besonderer Rücksicht auf die jüngsten Erfahrungen in England und Frankreich.* Hamburg, 8vo. pp. 50. (A sensible, calm and cautious exposition of ether inhalation, in which the author has compared and arranged with great judgement all that had been published on the subject up to the period when his work was written.—*American Journ. Med. Sci.*, April 1840, p. 523).

Roux J. *Éthérisme à l'aide du sac à étherisation.* Paris, 8vo. pp. 16.

Schenk C. *Die Einathmung der Schwefel-Äther-Dünste zur Verhutung u. Tilgung der Schmerzen.* Quedlinburg, 8vo. pp. 45, tab. i, 4to.

Simpson Sir JY. *Account of a new Anaesthetic agent (Chloroform) as a substitute for Sulphuric Ether in surgery and midwifery.* (Issued November 1847.) Edinburgh, 8vo. pp. 23.

Simpson Sir JY. *Answer to the Religious Objections advanced against the employment of Anaesthetic agents in midwifery and surgery.* Edinburgh, 8vo. pp. 24.

Simpson Sir JY. *Notes in the Inhalation of Sulphuric Ether in the practice of midwifery.* Edinburgh, 8vo.

Simpson Sir JY. *Remarks on the superinduction of Anaesthesia in natural and morbid parturition.* Edinburgh, 8vo.

Warren J, Mason. *On the Inhalation of Ether.* (Ex *Boston Med. Surg. Journ.*, March 1847.) Boston, 8vo. pp. 18.

Wells, H. *History of the application of Nitrous Oxide Gas, Ether, and other vapours to surgical operations.* Hartford, US, 12mo, pp. 25. [Also listed as published in Boston].

1847 Publications listed by Professor Secher with pagination from Waring

Bergson J. *Die medicinische Anwendung der Atherdämpfe.* Berlin, 8vo. pp. 133. (Waring gives an extended title).

Bibra Ev. Harless E. *Die Wirkungen des Schwefeläthers in chemischer und physiologischer Beziehung.* Erlangen, pp. 190. (Waring wrote Bibra FE and Harless E.)

Brookes, W Philpot. *Practical remarks of the inhalation of the vapour of sulfuric ether illustrated with cases and the latest method of application with remarks as to the proper period to commence operation.* Princess St. Soho, London: John Churchill, pp. 68.

Cousin C. *Notice sur l'éther et son emploi dans les de la opérationes de la chirurgie dentaire.* Paris pp. 31. (Waring wrote . . . *sur l'éther et sur le chloroform et leur emploi . . .*)

Gnenser WL. *Uber Ather-Einathmungen während der Geburt.* Leipzig, pp. 68. (Waring wrote Gresner).

Hammer A. *Die Anwendung des Schwefeläthers im Allgemeinen und insbesondere bei Geburten.* Mannheim, pp. 32.

Jenny JJ. *Erfahrungen über die Wirkungen der eingeathmeten Schwefelatherdämpfe.* Zurich, pp. 74. (Waring wrote Jenni).

Kopezky B. *Warnungen von den schädlichen Wirkungen der Aether-Einathmung.* Wien, pp. 43. (Waring gives an extended title).

Lach FL. *De l'éther sulfurique, de son action physiologique, et de son application à la chirurgie, aux accouchements, à la médicine; avec une aperçu historique sur la découverte de Jackson.* Paris, pp. 316.

Martin A. *Zur Physiologie und Pharmakadynamik des Aetherismus.* Munchen, pp. 115.

Rosenfeld J. *Die Schwefeläther-Dämpfe und ihre Wirksamkeit, vorzüglich in Bezug auf operative Chirurgie.* Pest (Hungary). pp. 72 (published in Leipzig according to Waring).

Schleisinger J. *Die Einathmung der Schwefel-Athers in ihren Wirkungen auf Menschen und Thiere, besonders als Mittel bei chirurgischen Operationen den Schmerz zu ungehen.* Leipzig, pp. 48.

Siebold ECJv. *Uber die Anwendung der Schwefeläther-Dämpfe in der Geburtshülfe.* Gottingen, pp. 27.

Warren E. *Some account of the letheon; or, who was the discoverer?* Boston, pp. 88. (Waring added 'with supplement').

Welz Rv. *Die Einathmung der Ather-Dampfe in ihrer verschiedenen Wirkungsweise.* Wurzburg, pp. 28.

Vallecular cysts

We read with interest the case reports of difficult intubations in patients with vallecular cysts. (*Anaesthesia* 1987; **42:** 407–10). We would like to report a rather younger patient with this condition.

The patient, a boy aged 7 years, was scheduled for antral washouts and adenoidectomy, after presenting with nasal stuffiness and snoring at night. He was otherwise well, and both growth and school performance were normal. No abnormalities were found on examination apart from enlarged adenoids on indirect pharyngoscopy.

Premedication was with trimeprazine 3 mg/kg and Emla cream to one hand. Thiopentone (6 mg/kg) and suxamethonium (1.5 mg/kg) were given through a winged needle. Ventilation of the lungs was easy after relaxation had occurred but laryngoscopy revealed a large cyst 3 × 4 cm which arose from the left valleculum and totally obscured the glottis. External manipulation of the larynx, and pushing the mass to one side with the tracheal tube, failed to reveal the glottis. Blind intubation was achieved eventually by using a tube one size smaller than usual, bent into a double curve on a malleable introducer (Fig. 1). The child was extubated deep at the conclusion of the operation, lying on his left side. Recovery was uneventful.

The mother afterwards revealed that her son sometimes snored while eating, and that he used to flex his neck laterally on swallowing. She thought that this was an affectation, and thus did not mention it. In retrospect it seems likely that this was as a result of the cyst.

This case reinforces the wisdom of the 'Be prepared' motto restated by Drs Mason and Wark. Given that these difficul-

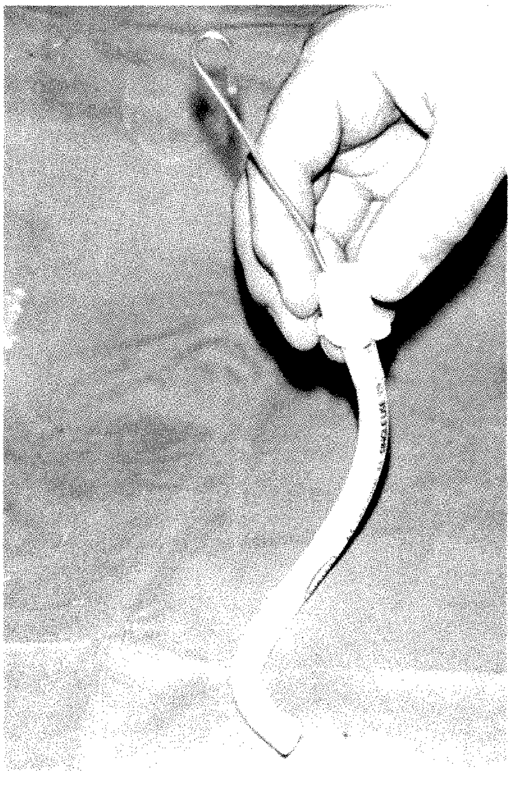

Fig. 1.

ties can present to anaesthetists at all levels of experience, contingency plans to cope with difficult intubations should be taught early in anaesthetic training.

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Anaesthetic practice and neuroradiology

Over the years the role of the anaesthetist in cerebral angiography has changed. The direct carotid approach has been replaced largely by femoral artery catheterisation, which makes the procedure much less distressing for the patient. The introduction of isotonic contrast media has also helped to make the procedure more acceptable under local anaesthesia, particularly for investigations limited to the carotid circulation. Painful sensation and patient movement are observed more frequently during investigation of the vertebral circulation. The results of a recent survey of neurosurgical units within the United Kingdom[1] revealed that there is a distinct bimodal pattern in the selection of either local anaesthesia with sedation, or general anaesthesia for cerebral angiography (Fig.1).

Fifteen out of 27 departments used general anaesthesia for 85% or more patients, and only five departments used local anaesthesia for the same proportion of patients. A mean value of 70% overall was obtained for general anaesthesia. The criteria for selection of patients for either group reflected a departmental policy approach rather than patient selection. The techniques were relatively uniform when general anaesthesia was used; intravenous induction was with a barbiturate (91%) and maintenance with either an opiate (37%) or a volatile anaesthetic agent (63%). All respondents used a tracheal technique and ventilation was controlled in 88% of cases. The administrator of anaesthesia was a consultant in 70% of routine cases, and the number of centres reporting adequate facilities for induction and recovery from anaesthesia within the X ray department was 30%.

The preference for general anaesthesia in this context is largely historical and reflects the early improvements made in X ray imaging by controlled ventilation during direct carotid and vertebral artery puncture.[2,3] The patients at this time were often suffering from the effects of raised intracranial pressure beforehand, and were subjected to repeated neck vessel puncture and injection of high osmolality contrast media. Spontaneous ventilation of volatile agents, often led to deterioration in the patient's condition as a result of increasing intracranial pressure and cerebral irritation. More recently, satisfactory results have been reported in detail from one neurosurgical centre which uses low osmolality contrast injection, by the femoral route, and employs a combination of local anaesthesia and sedation.[4] It is clear that the choice of general anaesthesia over local anaesthesia will have a profound effect on the morbidity associated with cerebral angiography as well as manpower requirements for anaesthetic staff. Every effort should be made to ensure that patients are selected carefully for general anaesthesia according to need, and thus avoid unnecessary administration of anaesthetics, particularly in an area where the hazards for the patient and anaesthetist are greater than inside the operating theatre environment.[4] Finally, there is an obvious necessity to increase the provision of adequate facilities for the induction of, and recovery from, anaesthesia within X ray departments in our hospitals, especially in those where the rate of administration of anaesthetics for angiography is high.

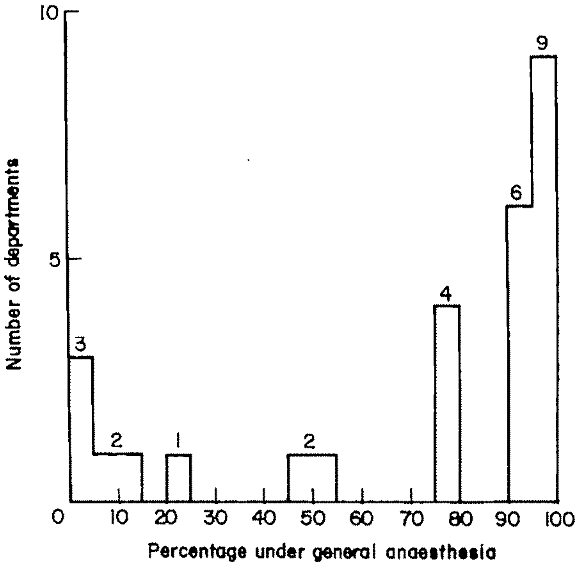

Fig. 1.

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References

1. Wright PJ. Tracheal tubes for neuroanaesthesia. *Anaesthesia* 1988; **43:** 258–9.
2. Edmonds-Seal J, Boulay G du, Bostick T. The effect of intermittent positive pressure ventilation upon cerebral angiography with special reference to the quality of the films—a preliminary communication. *British Journal of Radiology* 1967; **40:** 957–8.
3. Dallas SH, Moxon CP. Controlled ventilation for cerebral angiography. *British Journal of Anaesthesia* 1969; **41:** 597–602.
4. Walters FJM, Anaesthesia for neuroradiology. *British Journal of Hospital Medicine* 1987; **38:** 351–6.

Submucous fibrosis

Submucous fibrosis (SMF) is a common condition in countries where Betel nuts are chewed habitually. It has been estimated that 10% of the world's population chew Betel nuts[1] and that one person in a thousand of the Indian population may have SMF.[2]

A 62-year-old Bangladeshi woman presented for dental clearance. She had buccal SMF and previously had a squamous cell carcinoma of the palate treated by radiotherapy which had caused radiation osteitis of the temporomandibular joints. These problems combined to cause complete trismus with an overbite of 8 mm. The patient was intubated nasotracheally with the aid of a fibreoptic bronchoscope, sedation and local anaesthesia because of the risk of distorted airway anatomy and after careful discussion through an interpreter.

SMF is widely accepted to be a collagen disease of insidious onset associated with chronic local irritation.[3] The incidence is highest between 30 and 50 years of age.[4] There is an association with chili eating and tobacco chewing and with chewing of the betel nut (*Areca catechu*) which is a common habit among poorer Indian and Oriental races[5] in whom the disease may be associated with up to 40% of oral cancer affecting the palate, tongue and buccal mucosa.[6,7] The incidence of oral carcinoma has been reported to be up to 23% in the presence of SMF.[5]

Trismus, often severe, has been reported in a high proportion of patients by several authors[4,8] and SMF of the tongue and floor of the mouth is associated with limitation of tongue movement.[4] The extreme degree of trismus in this case illustrates a previously unreported anaesthetic problem of a common disease worldwide.

SMF, carcinoma and radiotherapy combined to cause a potential airway problem which must be repeated many times in patients from regions where betel nut chewing is endemic.

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References

1. Simpson W. Submucous fibrosis. *British Journal of Oral Surgery* 1969; **6:** 196–200.
2. Fendell LD, Smith FR. Betel-nut associated cancer: report of case. *Journal of Oral Surgery* 1970; **28:** 455–6.
3. Sirsat SM, Khanolkar VR. Submucous fibrosis of the palate and pillars of the fauces. *Indian Journal of Medical Science* 1962; **16:** 189–97.
4. Shiau YY, Kwan HW. Submucous fibrosis in Taiwan. *Oral Surgery, Oral Medicine, Oral Pathology* 1979; **47:** 453–7.
5. Pindborg JJ, Sirsat SM. Oral submucous fibrosis. *Oral Surgery, Oral Medicine, Oral Pathology* 1966; **22:** 764–79.
6. Pindborg JJ, Zachariah J. Frequency of oral submucous fibrosis among 100 South Indians with oral cancer. *Bulletin of WHO* 1965; **32:** 750–3.
7. Ashby J, Styles JA, Boyland E. Betel nuts, arecaidine, and oral cancer. *Lancet* 1979; **i:** 112.
8. Pindborg JJ, Chawla TN, Srivastava AN, Gupta D, Mehrotra ML. Clinical aspects of oral submucous fibrosis. *Acta Odontologica Scandinavica* 1964; **22:** 679–91.

An unexpected cause of total expiratory obstruction

A 67-year-old man was admitted electively to the Intensive Care Unit (ICU) after repair of an aortic aneurysm and insertion of an aortobifemoral graft. He had a history of chronic bronchitis and emphysema and had developed a spontaneous, right-sided tension pneumothorax during anaesthesia, probably as a result of rupture of an emphysematous bulla at the start of positive pressure ventilation of his lungs. This was managed by insertion of an underwater sealed intercostal drain, which was swinging freely with ventilation at the end of surgery. A chest radiograph on admission to ICU showed both lungs to be fully expanded.

Ventilation was instituted using a Puritan–Bennet 7200a ventilator, in the synchronised intermittent mandatory ventilation (SIMV) mode with a tidal volume of 0.85 litre and respiratory rate of eight breaths/minute. Peak airway pressure was 2.9 kPa. Later in the day he was started on treatment with salbutamol by nebuliser through a T-piece inserted into the ventilator system between the Y-piece and the catheter mount. Shortly after beginning to receive the first dose, the patient became acutely hypotensive, and airway pressure increased to greater than 6.0 kPa. On examination, the intercostal drain was still bubbling, but inspection and auscultation revealed that only the left side of the chest was being ventilated effectively, and a diagnosis of a tension pneumothorax was made.

Preparations were made to insert a further intercostal drain, and the patient was disconnected from the ventilator and hand ventilated with 100% oxygen through a Mapleson C system. His condition improved rapidly; ventilation became more easy, and blood pressure was stabilised. The nebuliser unit, an Intersurgical Cirrus (ref: 1501) was then examined closely. On this occasion the T-piece used was not one from the Intersurgical nebuliser kit (ref: 2505) but one supplied separately (ref: 1982), and had been taken from a box of loose connectors. The cause of the problem was found to be a unidirectional silicone disk-valve (Intersurgical ref: 1920) which was positioned within the male fitting of the cross-piece of the T and connected directly in series with the catheter mount; this permitted inspiration but prevented expiration.

These valves are designed to be used in a number of circumstances, such as for IMV entrainment (ref: 1952), when the presence of the valve is indicated by a yellow warning band. We remain unsure how the valve appeared in our ICU since it had never been ordered and there is no record of its delivery. Examination of our remaining stock of loose connectors revealed another T with an unidirectional valve in place.

The event is important because of the dangers associated with the incorrect use of systems with one-way valves. It is clear that the valve originated from the company in the past, perhaps as a sample, and there are two ways to explain how it came to lie within this T-connector. A valve was somehow loose in our box of connectors and found its way into the a plain T; or the company supplied a T-piece with a valve in place and the yellow warning band was either not sited or became detached.

Intersurgical do not have a T-piece arrangement like this in their catalogue and have no record of such events occurring in the past, so consequently cannot shed any light on the episode. However, the incident emphasises that staff who use equipment must be familiar with its design and function; the importance of the ability to recognise irregularities, especially if use is nonstandard or involves the re-use of disposable equipment is clear.

This is another incident which stresses the need to check all equipment before use.

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K.G. Stewart
A. Cohen

A reply

Dr Cohen makes a valid point. It is essential that staff using any equipment must be familiar with its design and function and be able to recognise irregularities.

Intersurgical assemble and supply items, such as the In-Line Nebulizer Kit, in clearly marked sealed packages. Staff who break the seal of any pack can be confident that the Kit is ready for use without modification. This policy was adopted to reduce this type of incident.

The re-use of connectors and their assembly in various breathing systems has often been a cause of problems.

Single-use prepacked systems, like those supplied by Intersurgical, reduce this problem. Intersurgical's sealed products have been designed for a specific task and the company cannot accept responsibility for products which have been modified with a component from an unknown source.

It was most unfortunate that the T-piece provided with the Cirrus nebuliser kit 2505 had been removed, as such practice clearly creates potential hazards and we agree with Dr Cohen's advice.

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R.B. HICKS

Misuse of adhesive tape

This is a report of another potential hazard of anaesthetic equipment, which could be prevented by a modification in manufacture.

This department uses Mediplast semidisposable Bain systems and has elected to replace them only when a fault occurs. Thus this particular system may have been in use for some time.

The system passed all the standard tests for leaks and misconnexions when the anaesthetic machine and equipment were checked before use. However, on using the oxygen flush, the reservoir bag did not deflate as briskly as usual. Investigation revealed that the outer lumen was almost completely blocked by adhesive tape; presumably this was placed around the distal connector to improve the fit of the tubing onto the connector. The tape was very difficult to see through the corrugated tubing, or through the lumen of the connector.

There can be only strong disapproval of such repairs, particularly since the policy of this department is to replace such faulty items. However, the problem would not have occurred had the tubing been permanently attached to the distal connector by the manufacturer.

This report demonstrates that safety checks are not 'all or nothing' and that they should be performed critically and carefully.

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J.R. DAVIES

A reply

The item in question was a single-use disposable product not intended for repair or re-use. The instructions for use enclosed in the product packaging clearly state 'single-patient use and may not be re-used or sterilized'.

We are aware some customers do re-use our disposable systems but it is not a practice Mediplast recommends or supports and we can take no responsibility for products used in a manner contrary to our published instructions for use.

Mediplast Ltd,
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G. YOUNG

How much blood for a blood gas?

Anaemia is found commonly in patients admitted to the Intensive Therapy Unit (ITU) for prolonged periods. There are many causes, which include bone marrow failure, relative vitamin deficiency, haemolysis, disseminated intravascular coagulopathy, revealed or concealed haemorrhage (as a result either of surgery or a bleeding diathesis). Part of this anaemia is iatrogenic. The average length of stay in this unit is 5.9 days (1987). Sixty millilitres of blood is withdrawn on admission for multiple investigations and serum saving. Thereafter, at least 15 ml of blood is taken each day for haematological and chemical pathological investigation. A further 30 ml may be drawn for blood cultures. The number of blood gas measurements is variable, but can be large. Under normal circumstances, about 1% of red cell mass is renewed daily (with a corresponding reticulocyte count of 1%). Assuming a blood volume of

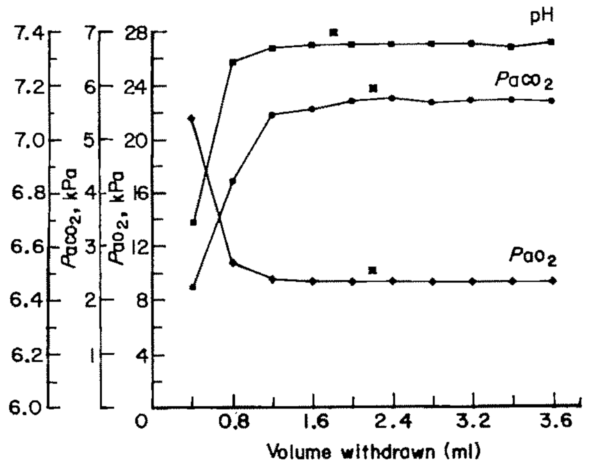

Fig. 1. pH, $P\text{CO}_2$ and $P\text{O}_2$ values for successive 0.4 ml samples withdrawn from an arterial cannula–catheter–tap system. The * indicates that there is no difference between the two adjacent samples ($p > 0.5$).

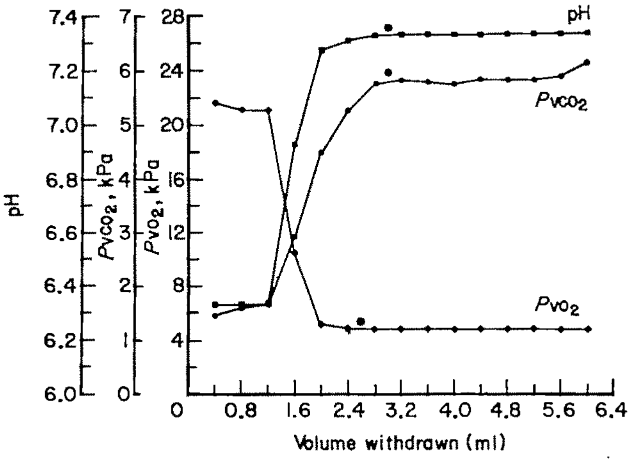

Fig. 2. pH, $P\text{CO}_2$ and $P\text{O}_2$ values for successive 0.4 ml samples withdrawn from a pulmonary artery catheter–tap system. The * indicates that there is no difference between the two adjacent samples ($p > 0.5$). For obvious reasons, no analysis was applied to the first three samples.

approximately 5 litres, the normal marrow replaces 50 ml of blood each day. A failing marrow must supply sufficient red cells to cover this and any further loss.

Many patients in the ITU have arterial or pulmonary artery lines in place. The dead volume must be cleared before sampling and this is blood wasted. There is a routine order to discard 3 ml of blood in this ITU from arterial lines (5 ml if clotting studies alone are being performed) and 5 ml for pulmonary artery catheters. There is little prospect for reducing blood loss other than for that which is used for measurement of blood gases.

We sought to reduce our wastage by determining the minimum quantity of blood necessary to produce stable blood gas measurements. Our cannula–catheter–tap arrangement is standard for either arterial or pulmonary artery catheters, so the results are applicable for all patients. In a single stable patient we performed blood gas measurements on 10 consecutive 0.4 ml aliquots of blood removed from an indwelling arterial cannula. In a second experiment on a different patient, a similar study was repeated for a pulmonary artery flotation catheter, but in this case 15 consecutive 0.4 ml samples were removed. Each experiment was repeated a further four times. Our results (see Figs 1 and 2) show that for our arterial line study, a sample volume of 1.6 ml was required before stable blood gas measurements were obtained. For our pulmonary artery study, the sample size needed was 2.8 ml. We noticed that the sample appeared to be 'blood' after the third arterial 'aliquot' was removed, but acceptance of a result on this sample would have led to erroneous therapy. The dead space volume of our cannula–catheter–tap system for the arterial line is 0.65 ml and for the pulmonary artery catheter–tap system is 1.05 ml. The volumes removed before the attainment of stable blood gas readings were approximately three times the dead space of our system, as might be expected from simple wash-in exponential principles.

Each ITU should determine its own system volume in order to minimise excessive blood wastage when performing multiple blood gas estimations on patients. This may go some way towards reducing the incidence of iatrogenic anaemia.

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Program for BBC B microcomputer to record data from anaesthetic monitoring equipment

Data recorded by anaesthetic monitoring equipment commonly follows a wave pattern with alternating troughs and peaks, (direct blood pressure monitoring, end-tidal CO_2, airway pressure, volatile agent concentration). The monitor usually outputs this data in analogue form.

Storage of this type of data for research purposes is usually on paper. Calibration of the writer is required beforehand and later the printout is analysed manually by measuring the heights of the deflections on the paper. This is time consuming and may lead to inaccuracy if the levels of the peak and trough are measured incorrectly. Thus for data storage and analysis for research purposes it would be more useful to convert the data to digital form.

Our program was written to record peak and trough concentrations of volatile agents (inspired and alveolar concentrations) as measured at the tip of the tracheal tube during controlled ventilation, but it could be used to record any physiological data that varies in a wave-like pattern with time. It makes use of the analogue to digital convertor on the BBC microcomputer (model B, Acorn Computers). This gives a consistent digital output for a given analogue input after an initial warm-up period of 15 minutes.

Calibration is carried out using a zero point and the input of a known value of the variable being measured. The analogue input from the monitor is sampled every 10 milliseconds when analysis starts and is converted to digital data. The digital data is analysed to find the minimum and maximum values for the variable during a given sampling period. This gives a figure for the peak and trough values of the variable during the sampling period (in our case inspired and alveolar concentrations).

We used a rolling mean of 20 consecutive readings for the purposes of our study (that is the mean value over 0.2 seconds) rather than a single reading, in order to reduce the chances of an artificially high or low reading as a result of a short-lived fluctuation in analogue input. The program could be changed easily to give a mean value over a shorter period of time if a variable with a higher frequency was studied.

This program could be used to record and store data from monitors which measure direct arterial pressure, end-tidal CO_2 concentrations, or airway pressure. It also records the mean value of the variable during the sampling period; the data is stored on a second disc as it is recorded and can be retrieved later for printing.

The program is menu-driven, and asks initially for the patient's name and hospital number and then moves on to the calibration routine. The duration of sampling, the time interval between sampling and the number of samples can be altered from the default values if required. A stat reading can be taken at any time during the study by pressing the SPACE bar.

In summary, this program converts waveform data from analogue to digital form; this allows convenient storage and analysis of data for research purposes.

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The use of propofol for anaesthesia for electroconvulsive therapy

We were interested to read the preliminary report by Rouse concerning the use of propofol for anaesthesia for electroconvulsive therapy (ECT) (*Anaesthesia* 1988; **43** (Suppl.): 61–4). Ten patients were given either propofol or methohexitone, repeated on two occasions, and seizure duration was timed. Mean seizure durations were 18.0 seconds after propofol and 30.8 seconds after methohexitone; thus propofol significantly reduced seizure duration. We reported previously a similar reduction in seizure duration after 25 patients received propofol for ECT;[1] we found that mean seizure duration was reduced from 35.3 seconds after methohexitone to 20.3 seconds after propofol. A recent study of electrical seizure duration, measured by simplified EEG, has shown that propofol significantly reduced mean electrical seizure time to 43.2 seconds compared with 57.3 seconds after methohexitone.[2]

We wondered whether the isolated arm technique, as recommended by Fink and Johnson,[3] was used by Rouse to measure seizure quality and duration; this technique correlates highly with EEG measurement of seizure duration, and prevents partial paralysis with suxamethonium from influencing the results. We do not consider that the quality of the seizure can be commented upon if the isolated arm is not used to exclude the effects of the relaxant. Seizure duration is related to the dose of methohexitone used[4] so we were concerned that the doses of methohexitone and propofol were titrated, rather than standardised, in the study by Rouse. It is possible that different subjects received different relative doses of the two drugs, which may therefore alter the seizure duration independent of any direct effect of the induction agents. The mode of ventilation of the lungs also alters seizure duration during ECT;[5] was ventilation prior to application of the ECT stimulus standardised?

Notwithstanding the above points, the study confirms that the use of propofol reduces ECT seizure duration. Two of the 25 subjects in our study did not have seizures after propofol, even though they had adequate seizures after methohexitone. We do not consider that propofol should be used for ECT until studies of its effect on the outcome of ECT treatment have been performed, in view of the controversy with regard to the relationship between seizure duration and ECT's efficacy. Such work requires close cooperation between anaesthetists and psychiatrists and raises important, and difficult, ethical problems.

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References

1. Simpson KH, Halsall PJ, Carr CME, Stewart KG. Seizure duration after methohexitone or propofol for induction of anaesthesia for electroconvulsive therapy (ECT). *British Journal of Anaesthesia* 1987; **59:** 1323P–4P.
2. Dwyer R, McCauchey W, Lavery J, Dundee JW. Comparison of propofol and methohexitone as anaesthetic agents for electroconvulsive therapy. Presented to Anaesthetic Research Society Meeting, November 1987. *British Journal of Anaesthesia* 1988; (in press).
3. Fink M, Johnson L. Monitoring the duration of electroconvulsive therapy seizures. 'Cuff' and EEG methods compared. *Archives of General Psychiatry* 1982; **39:** 1189–91.
4. Miller AL, Faber RA, Hatch JP, Alexander HE. Factors affecting amnesia, seizure duration, and efficacy in ECT. *American Journal of Psychiatry* 1985; **142:** 692–6.
5. Chater SN, Simpson KH. Effect of passive hyperventilation on seizure duration in patients undergoing electroconvulsive therapy. *British Journal of Anaesthesia* 1988; **60:** 70–3.

Editor's note

Dr Rouse has no comment.

Anaesthesia, 1988, Volume 43, pages 814–820

Anaesthetic literature

This section of *Anaesthetic literature* contains references taken from *Current Contents—Life Sciences* for May 1988. The Journals which may be consulted when *Anaesthetic literature* is compiled are those listed in *Current Contents—Life Sciences*, published by the Institute of Scientific Information, Philadelphia, Pennsylvania, USA.

Abdominal surgery

Laser-Doppler flowmetry for estimating liver blood flow. Arvidsson D, Svensson H, Haglund U. *American Journal of Physiology* 1988; **254:** G471.

The role of somatostatic and serotonin in the beta-adrenoceptor regulation of gastric function—an experimental study in dogs. Bech K. *Danish Medical Bulletin* 1988; **35:** 122.

Role of sodium pump in membrane potential gradient of canine proximal colon. Burke EP, Reed JB, Sanders KM. *American Journal of Physiology* 1988; **254:** C475.

Regulation of gastrointestinal mucosal growth. Johnson LR. *Physiological Reviews* 1988; **68:** 456.

Hepatic ischemia: possible cause of hepatic dysfunction. Schirmer WJ, Schirmer JM *et al. Archives of Surgery* 1988; **123:** 412.

Pharmacology

Adrenergic drugs and their antagonists

Long-term evaluation of 0.25% levobunolol and timolol for therapy for elevated intraocular pressure. Boozman FW, Carriker R *et al. Archives of Ophthalmology* 1988; **106:** 614.

Biochemistry and pharmacology of the alpha-1 adrenergic receptor. Bylund DB. In: Ruffolo RR, ed. *Alpha-1 adrenergic receptors.* Clifton: Human Press, 1987: 19.

Neurogenic histaminergic vasodilation in canine skeletal muscle: Mediation by alpha 2-adrenoceptor stimulation. Camazine B, Shannon RP *et al. Circulation Research* 1988; **62:** 871.

Beta-blockade antagonism of tyramine-induced rise in blood pressure. Colombo F, Sega R *et al. European Journal of Clinical Pharmacology* 1988; **34:** 263.

Structure activity relationships for alpha-1 adrenergic receptor agonists and antagonists. DeMarinis RM, Wise M *et al.* In: Ruffolo RR, ed. *Alpha-1 adrenergic receptors.* Clifton: Human Press, 1987: 211.

Epinephrine facilitates neurogenic vasoconstriction in humans. Floras JS, Aylward PE *et al. Journal of Clinical Investigation* 1988; **81:** 1265.

Noradrenaline response to edrophonium in primary autonomic failure: distinction between central and peripheral damage. Gemmill JD, Venables GS, Ewing DJ. *Lancet* 1988; **1:** 1018.

The effect of beta-blockers on mental performance on older hypertensive patients. Gengo FM, Fagan SC *et al. Archives of Internal Medicine* 1988; **148:** 779.

Regulation of alpha-1 adrenergic receptors. Hoffman BB. In: Ruffolo RR, ed. *Alpha-1 adrenergic receptors.* Clifton: Human Press, 1987: 457.

Effect of beta-adrenergic blockade on the growth rate of abdominal aortic aneurysms. Leach SD, Toole A *et al. Archives of Surgery* 1988; **123:** 606.

Alpha-1 adrenergic receptors—a historical perspective. Pettinger WA, Smyth DD. In: Ruffolo RR, ed. *Alpha-1 adrenergic receptors.* Clifton: Human Press, 1987: 3.

Anaesthetic agents

Impact of surgical stress on the haemodynamic profile of isoflurane-induced hypotension. Bernard JM, Pinaud M *et al. Acta Anaesthesiologica Scandinavica* 1988; **32:** 248.

Neuronal intracellular calcium concentrations are altered by anesthetics–relationship to membrane fluidization. Daniell LC, Harris RA. *Journal of Pharmacology and Experimental Therapeutics* 1988; **245:** 1.

Mechanism of halothane-induced hepatotoxicity: another step on a long path. Gelman S, Van Dyke R, *Anesthesiology* 1988; **68:** 479.

Halothane hepatitis patients generate an antibody response toward a covalently bound metabolite of halothane. Hubbard AK, Roth TP *et al. Anesthesiology* 1988; **68:** 791.

Effects of isoflurane on myocardial metabolism during post-ischaemic reperfusion in the rat. Kashimoto S. *Acta Anaesthesiologica Scandinavica* 1988; **32:** 199.

Propofol: a review of its pharmacodynamic and pharmacokinetic properties and use as an intravenous anaesthetic. Langley MS, Heel RC. *Drugs* 1988; **35:** 334.

Ventilatory responses to lung inflation and arterial CO_2 in halothane-anesthetized dogs. Mitchell GS, Selby BD. *Journal of Applied Physiology* 1988; **64:** 1433.

Respiratory effects of nitrous oxide during halothane or enflurane anaesthesia in children. Murat I, Lebret F *et al. Acta Anaesthesiologica Scandinavica* 1988; **32:** 186.

Halothane attenuation of muscarinic inhibition of adenylate cyclase in rat heart. Narayanan TK, Confer RA *et al. Biochemical Pharmacology* 1988; **37:** 1219.

Halothane hepatotoxicity and reductive metabolism of halothane in acute experimental liver injury in rats. Nomura F, Hatano H *et al. Anesthesia and Analgesia* 1988; **67:** 448.

Comparative toxicity of halothane, isoflurane, hypoxia, and phenobarbital induction in monolayer cultures of rat hepatocytes. Schieble TM, Costa AK *et al. Anesthesiology* 1988; **68:** 485.

GABA-related drugs modulate the behavioral effects of lorazepam. Wettstein JG, Spealman RD. *Psychopharmacology* 1988; **95:** 38.

Analgesic agents

Effects of neuroleptic treatments on peripheral opioid secretion. Brambilla F, Facchinetti F *et al. Neuropsychobiology* 1987; **18:** 68.

Morphine-induced immunomodulation is not related to serum morphine concentrations. Bryant HU, Yoburn BC *et al. European Journal of Pharmacology* 1988; **149:** 165.

Human cardiovascular reactions to simulated hypovolaemia, modified by the opiate antagonist naloxone. Foldager N, Bondepetersen F. *European Journal of Applied Physiology and Occupational Physiology* 1988; **57:** 507.

Epidural sufentanil for intraoperative and postoperative analgesia in thoracic surgery: A comparative study with intravenous

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The collator of this section is Dr L. Kaufman, MD, FFARCS, Anaesthetic Office, The Rayne Institute, University College, University Street, London WC1E 6JJ. Dr Kaufman is prepared to provide on request a new additional service to our readers. References from January 1984 have been entered on a data base using Dbase III Plus (MsDos) and this will be upgraded in the near future to Dbase IV. The Program which provides search facilities will be available free of charge save for the cost of the disk. In addition, all the data on a yearly or monthly basis will be available at a modest charge. Enquiries direct to Dr Kaufman at the above address please.

sufentanil. Rosseel PMJ, Vandenbroek WGM *et al. Acta Anaesthesiologica Scandinavica* 1988; **32:** 193.

Naloxone-like influence of TRH and ACTH-(4-7) on hypothalamic blood flow autoregulation in the rat. Sandor P, De Jong W, De Wied D. *Peptides* 1988; **9:** 215.

Muscle relaxants

Myasthenia gravis and primary squamous cell carcinoma of the thymus—a case report. DiMario FJ, Lisak RP *et al. Neurology* 1988; **38:** 580.

Maintenance of constant 95-percent neuromuscular blockade by adjustable infusion rates of pancuronium and atracurium. Haraldsted VY Nielsen JW *et al. British Journal of Anaesthesia* 1988; **60:** 491.

Halothane-caffeine contracture testing in neuromuscular diseases. Heiman-Patterson TD, Rosenberg H *et al. Muscle and Nerve* 1988; **11:** 453.

Muscle fatigue and pain after eccentric contractions at long and short length. Newham DJ, Jones DA *et al. Clinical Science* 1988; **74:** 553.

Expression of ACh-activated channels and sodium channels by messenger RNAs from innervated and denervated muscle. Parker I, Sumikawa K *et al. Proceedings of the Royal Society of London* 1988; **233:** 235.

Differential effects of calcium channel blocking agents on pancuronium-induced and suxamethonium-induced neuromuscular blockade. Salvador A, Delpozo E *et al. British Journal of Anaesthesia* 1988; **60:** 495.

Clinical pharmacology of doxacurium chloride (BW A938U) in children. Sarner JB, Brandom BW *et al. Anesthesia and Analgesia* 1988; **67:** 303.

The clinical neuromuscular pharmacology of mivacurium chloride: A short-acting nondepolarizing ester neuromuscular blocking drug. Savarese JJ, Ali HH *et al. Anesthesiology* 1988; **68:** 723.

A myasthenic syndrome with congenital paucity of secondary synaptic clefts: CPSC syndrome. Smit LME, Hageman G *et al. Muscle and Nerve* 1988; **11:** 337.

Spontaneous transmitter release at the neuromuscular junction. Thesleff S. *Fundamental and Clinical Pharmacology* 1988; **2:** 89.

Neuromuscular disorders and thymoma. Witt NJ, Bolton CF. *Muscle and Nerve* 1988; **11:** 398.

Other drugs

Problems in therapeutic drug monitoring: free drug level monitoring. Barre J, Didey F *et al. Therapeutic Drug Monitoring* 1988; **10:** 133.

Physiologically based models and strategic experiments in hepatic pharmacology. Bass L, Keiding S. *Biochemical Pharmacology* 1988; **37:** 1425.

New drugs: practical clinical pharmacology: drug handling and response. Feely J, Brodie MJ. *British Medical Journal* 1988; **296:** 1046.

Minireview: Biochemical mechanisms of cephaloridine nephrotoxicity. Goldstein RS, Smith PF *et al. Life Sciences* 1988; **42:** 1809.

The effect of peroxisome proliferators on microsomal, peroxisomal, and mitochondrial enzyme activities in the liver and kidney. Hawkins JM, Jones WE *et al. Drug Metabolism Reviews* 1987; **18:** 441.

Kinetics of drug effects in man. Oosterhuis B, Van Boxtel CJ. *Therapeutic Drug Monitoring* 1988; **10:** 121.

Therapeutic drug monitoring. Spector R, Park GD *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 345.

Concentration profile in plasma after transdermal drug delivery. Tojo K. *International Journal of Pharmaceutics* 1988; **43:** 201.

Behavioural effects of histamine and its antagonists: a review. White JM, Rumbold GR. *Psychopharmacology* 1988; **95:** 1.

Apparatus

Central catheter infections: single- versus triple-lumen catheters, influence of guide wires on infection rates when used for replacement of catheters. Hilton E, Haslett TM *et al. American Journal of Medicine* 1988; **84:** 667.

Tracheal tube cuff pressure. Clinical use of the Cardiff cuff controller. Willis BA, Latto IP, Dyson A. *Anaesthesia* 1988; **43:** 312.

Complications

Aspiration resulting from gastroesophageal reflux—a cause of chronic bronchopulmonary disease. Johnson LF, Rajagopal KR. *British Heart Journal* 1988; **59:** 676.

Massive air embolism in an adult following positive pressure ventilation. Kane G, Hewins B, Grannis FW. *Chest* 1988; **93:** 874.

Drug nephrotoxicity. Walker RJ, Duggin GG. *Annual Review of Pharmacology and Toxicology* 1988; **28:** 331.

General anaesthetic procedures

Patient monitoring. Emmett C, Hutton P. *British Medical Bulletin* 1988; **44:** 302.

Anesthesia for ophthalmic surgery in elderly: The effects of clonidine on intra-ocular pressure, perioperative hemodynamics and anesthetic requirement. Ghignone M, Noe C *et al. Anesthesiology* 1988; **68:** 707.

Perioperative myocardial ischemia: Importance of the preoperative ischemic pattern. Knight AA, Hollenberg M *et al. Anesthesiology* 1988; **68:** 681.

Effect of anaesthesia and surgery on pharmacokinetics and pharmacodynamics. Nimmo WS, Peacock JE. *British Medical Bulletin* 1988; **44:** 286.

Preoperative patient assessment. Norman J, Lorimer AR *et al. British Medical Bulletin* 1988; **44:** 247.

Thyroid and parathyroid surgery performed with patient under regional anesthesia. Saxe AW, Brown E, Hamburger SW. *Surgery* 1988; **103:** 415.

Does chronic treatment with calcium entry blocking drugs reduce perioperative myocardial ischemia? Slogoff S, Keats AS. *Anesthesiology* 1988; **68:** 676.

New routes of administration and new delivery systems of anesthetics. Stanley TH. *Anesthesiology* 1988; **68:** 665.

General interest

Congenital platelet disorders. Bellucci S, Caen JP. *Blood Reviews* 1988; **2:** 16.

Reflux oesophagitis and oesophageal transit—evidence for a primary oesophageal motor disorder. Eriksen CA, Sadek SA *et al. Gut* 1988; **29:** 448.

Advances in the diagnosis and treatment of pheochromocytoma. Havlik RJ, Cahow E *et al. Archives of Surgery* 1988; **123:** 626.

Characterization of immunoreactive dynorphin in human phaeochromocytomas. Howlett TA, Besser GM, Rees LH. *Journal of Endocrinology* 1988; **117:** 123.

Fatigue in multiple sclerosis. Krupp LB, Alvarez LA *et al. Archives of Neurology* 1988; **45:** 435.

Inherited factors in thrombosis. Mannucci PM, Tripodi A. *Blood Reviews* 1988; **2:** 27.

Surgical resection of carotid body tumors: long-term survival, recurrence, and metastasis. Nora JD, Hallett JW *et al. Mayo Clinic Proceedings* 1988; **63:** 348.

On the pathogenesis of portal hypertension in cirrhosis of the liver. Shibayama Y. *Liver* 1988; **8:** 95.

Consequences of blood loss on growth of artificial metastases. Singh SK, Marquet RL *et al. British Journal of Surgery* 1988; **75:** 377.

Neurofibromatosis associated with somatostatinoma: a report of two patients. Swinburn BA, Yeong ML *et al. Clinical Endocrinology* 1988; **28:** 353.

Third nerve palsy and the pupil: Footnotes to the rule. Trobe JD, Arbor A. *Archives of Opthalmology* 1988; **106:** 601.

Response of tumours to hyperglycaemia: characterization, significance and role in hyperthermia. Ward KA, Jain RK. *International Journal of Hyperthermia* 1988; **4:** 223.

Local analgesia

Cocaine and other stimulants: actions, abuse, and treatment. Gawin FH, Ellinwood EH Jr. *New England Journal of Medicine* 1988; **318:** 1173.

Lack of cardiovascular tolerance during intravenous cocaine infusions in human volunteers. Kumor K, Sherer M *et al. Life Sciences* 1988; **42:** 2063.

Regional anesthesia and surgical morbidity. Scott NB, Kehlet H. *British Journal of Surgery* 1988; **75:** 299.

Intrapleural administration of 0.25%, 0.375% and 0.5% bupivacaine with epinephrine after cholecystectomy. Stromskag KE, Reiestad F *et al. Anesthesia and Analgesia* 1988; **67:** 430.

Spinal opioids

Clinical experience of long-term treatment with epidural and intrathecal opioids—a nationwide survey. Arner S, Rawal N, Gustafsson LL. *Acta Anaesthesiologica Scandinavica* 1988; **32:** 253.

Evidence that activation of GABA receptors in the substantia nigra suppresses spontaneous spike-and-wave discharges in the rat. Depaulis A, Vergnes M *et al. Brain Research* 1988; **448:** 20.

Evidence that endogenous enkephalins and a δ-opioid receptor agonist have a common site of action in spinal antinociception. Dickenson AH, Sullivan AF, Roques BP. *European Journal of Pharmacology* 1988; **148:** 437.

Clonidine inhibits electrodermal responses by an action on the spinal cord. Koss MC, Hey JA. *European Journal of Pharmacology* 1988; **148:** 437.

Pharmacokinetic profile of epidural meperidine with and without dextran 70. Naguib M, Farag H *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 407.

Analgesia and ventilatory response to carbon dioxide after intramuscular and epidural alfentanil. Penon C, Negre I *et al. Anesthesia and Analgesia* 1988; **67:** 313.

Intrathecal oxymetazoline produces analgesia via spinal alpha-adrenoceptors and potentiates spinal morphine. Sherman SE, Loomis CW *et al. European Journal of Pharmacology* 1988; **148:** 371.

Pharmacology of dynorphin. Smith AP, Lee NM. *Annual Review of Pharmacology and Toxicology* 1988; **28:** 123.

Opioid treatment for radiating cancer pain—oral administration vs epidural techniques. Vainio A, Tigerstedt I. *Acta Anaesthesiologica Scandinavica* 1988; **32:** 179.

Modification of the response to opioid and nonopioid drugs by chronic opioid antagonist treatment. Yoburn BC, Inturrisi CE. *Life Sciences* 1988; **42:** 1689.

Efficacy and tolerance of narcotic analgesics at the Mu-opioid receptor in differentiated human neuroblastoma cells. Yu VC, Sadee W. *Journal of Pharmacology and Experimental Therapeutics* 1988; **245:** 350.

Obstetric anaesthesia and analgesia

Qualitative assessment of maternal uterine and fetal umbilical artery blood flow and resistance in laboring patients by Doppler velocimetry. Brar HS, Platt LD *et al. American Journal of Obstetrics and Gynecology* 1988; **158:** 952.

Arginine vasopressin and oxytocin in the porcine corpus luteum. Choy VJ, Watkins WB. *Neuropeptides* 1988; **11:** 119.

Recurrent herpes simplex virus labialis and the use of epidural morphine in obstetric patients. Crone L-A L, Conly JM *et al. Anaesthesia and Analgesia* 1988; **67:** 318.

The classification and definition of the hypertensive disorders of pregnancy. Davey DA, MacGillivray I. *American Journal of Obstetrics and Gynecology* 1988; **158:** 892.

Pregnancy and multiple sclerosis. Frith JA, McLeod JG. *Journal of Neurology, Neurosurgery and Psychiatry* 1988; **51:** 495.

Sustained effects of opioid antagonism during the normal human luteal phase. Gindoff PR, Jewelewicz R *et al. Journal of Clinical Endocrinology and Metabolism* 1988; **66:** 1000.

Continuous epidural infusion of 0.075% bupivacaine for pain relief in labour. A comparison with intermittent top-ups of 0·5% bupivacaine. Hicks JA, Jenkins JG *et al. Anaesthesia* 1988; **43:** 289.

Continuous infusion epidural analgesia in labor: The effect of adding sufentanil to 0.125% bupivacaine. Phillips G. *Anesthesia and Analgesia* 1988; **67:** 462.

Revised definition of pre-eclampsia Redman CWG, Jefferies M. *Lancet* 1988; **1:** 809.

Cerebral vasospasm and eclampsia. Trommer BL, Homer D, Mikhael MA. *Stroke* 1988; **19:** 326.

Determinants of morbidity in obese women delivered by cesarean. Wolfe HM, Gross TL *et al. Obstetrics and Gynecology* 1988; **71:** 691.

Paediatric anaesthesia and intensive care

Principles of drug biodisposition in the neonate: A critical evaluation of the pharmacokinetic-pharmacodynamic interface (Part I). Besundr JB, Reed MD, Blumer JL. *Clinical Pharmacokinetics* 1988; **14:** 189.

Closed chest cardiac massage in the newborn infant. David R. *Pediatrics* 1988; **81:** 552.

Plasma mineralocorticoids, glucocorticoids and progestins in premature infants: Longitudinal study during the first week of life. Doerr HG, Sippell WG *et al. Pediatric Research* 1988; **23:** 525.

Relationship between maternal and fetal lung growth. Faridy EE, Bucher S, Sanii MR. *Respiration Physiology* 1988; **72:** 171.

Air embolism in ventilated very low birthweight infants. Fenton TR, Bennett S, McIntosh N. *Archives of Disease in Childhood* 1988; **63:** 541.

Polysomnographic indications for surgery in Pierre Robin syndrome—acute airway management after repair and take-down of tongue-lip adhesion. Freed G, Pearlman MA *et al. The Cleft Palate Journal* 1988; **25:** 151.

Warm tub bath during labor. Effects on plasma catecholamine and beta-endorphin-like immunoreactivity concentrations in the infants at birth. Gradert Y, Hertel J *et al. Acta Obstetricia et Gynecologica Scandinavica* 1987; **66:** 681.

Catecholamine and blood pressure levels in paralysed preterm ventilated infants. Greenough A, Pool J, Lagercrantz H. *Early Human Development* 1988; **16:** 219.

Prevalence of mouthbreathing in cleft lip and palate. Hairfield WM, Warren DW, Seaton DL. *The Cleft Palate Journal* 1988; **25:** 135.

Pre-induction of anesthesia in pediatric patients with nasally administered sufentanil. Henderson JM, Brodsky DA *et al. Anesthesiology* 1988; **68:** 671.

Pulmonary surfactant. II. In sudden infant death syndrome. Hill CM, Brown BD *et al. Early Human Development* 1988; **16:** 153.

Pulmonary surfactant. I. In immature and mature babies. Hill CM, Brown BD *et al. Early Human Development* 1988; **16:** 143.

Improving pulmonary function does not decrease oxygen consumption in infants with bronchopulmonary dysplasia. Kao LC, Durand DJ, Nickerson BG. *Journal of Pediatrics* 1988; **112:** 616.

Diaphragmatic movement in newborn infants. Laing IA, Teele RL, Stark AR. *Journal of Pediatrics* 1988; **112:** 638.

Neonatal jaundice. Levine RL. *Acta Paediatrica Scandinavica* 1988; **77:** 177.

Analgesia in children after day-case surgery. Leading Article. *Lancet* 1988; **I:** 1084.

The neurological condition of the newborn infant with maternal hypertension examined at term. Martikainen MA, Airaksinen EM *et al. Early Human Development* 1988; **16:** 107.

Nebulised salbutamol does have a protective effect on airways in children under 1 year old. O'Callaghan C, Milner AD, Swarbrick A. *Archives of Disease in Childhood* 1988; **63:** 479.

Autonomic responses and neurohumoral control in the human early antenatal heart. Papp JG. *Basic Research in Cardiology* 1988; **83:** 2.

Effect of ventilation on mechanical properties and pressure-flow relationships of immature airways. Penn RB, Wolfson MR, Shaffer TH. *Pediatric Research* 1988; **23:** 519.

Prediction of the oxygenation of human organs at varying blood oxygen carrying properties. Samaja M. *Respiration Physiology* 1988; **72:** 211.

2,3-Diphosphoglycerate in normal, anaemic and transfused human fetuses. Soothill PW, Lestas AN *et al. Clinical Science* 1988; **74:** 527.

Cardiovascular system

Physiology

Current concepts in unstable myocardial ischemia. Bashour TT, Myler RK *et al. American Heart Journal* 1988; **115:** 850.

Cachectin, cachexia, and shock. Beautler B, Cerami A. *Annual Review of Medicine* 1988; **39:** 75.

Intracoronary infusion of dobutamine to patients with and without heart failure—correlation with catecholamines, phosphodiesterase inhibition. Colucci WS, Denniss AR *et al. Journal of Clinical Investigation* 1988; **81:** 1103.

Interactions between sodium and calcium intake and blood pressure responses to norepinephrine and parathyroid hormone. Doris PA. *Hormone and Metabolic Research* 1988; **20:** 163.

Current concepts: myocardial ischemia—silent or symptomatic. Epstein SE, Quyyumi AA, Bonow RO. *New England Journal of Medicine* 1988; **318:** 1038.

Correlation between beta-endorphin plasma levels and anginal symptoms in patients with coronary artery disease. Falcome C, Specchia G *et al. Journal of the American College of Cardiology* 1988; **11:** 719.

Cardiovascular responses to inhibition of alpha-adrenoceptors, the renin-angiotensin system and vasopressin in rats with adrenal regeneration hypertension. Foulkes R, Gardiner SM, Bennett T. *Journal of Hypertension* 1988; **6:** 305.

Impaired fibrinolysis in coronary artery disease. Francis RB Jr, Kawanishi D *et al. American Heart Journal* 1988; **115:** 776.

The reason for cardiac output reduction after aortic cross-clamping. Gelman S, McDowell H *et al. American Journal of Surgery* 1988; **155:** 578.

Measuring right ventricular volumes. Kass DA. *American Journal of Physiology* 1988; **254:** H619.

Relations of preoperative hemodynamics and coronary blood flow to improved left ventricular function after valve replacement for aortic regurgitation. Kawachi K, Kitamura S *et al. Journal of American College of Cardiology* 1988; **11:** 925.

Ventricular noradrenaline concentrations in naive and morphine-treated rats subjected to acute myocardial ischaemia. Ko WWW, Dai S, Chan MY. *British Journal of Pharmacology* 1988; **93:** 723.

Atrial natriuretic factor is detectable in human cerebrospinal fluid. Levin ER. *Journal of Clinical Endocrinology and Metabolism* 1988; **66:** 1080.

Use of cardiopulmonary bypass in studies of the circulation. Levy JH, Hug CC. *British Journal of Anaesthesia* 1988; **60** (Suppl. 1): S35.

Renal haemodynamics, sodium balance and the capacitance system in essential hypertension. London GM, Safar ME. *Clinical Science* 1988; **74:** 449.

Immunoreactive atrial natriuretic factor is increased in ovine model of endotoxemia. Lubbesmeyer HJ, Woodson L *et al. American Journal of Physiology* 1988; **254:** R567.

Editorial: assessment of myocardial function. Norman J, Sykes MK. *British Journal of Anaesthesia* 1988; **60** (Suppl. 1): S1.

Plasma atrial natriuretic polypetptide concentrations during and after reversion of paroxysmal supraventricular tachycardias. Oliver JR, Twidale N *et al. British Heart Journal* 1988; **59:** 458.

Neurohormonal interactions and adaptations in congestive heart failure. Packer M. *Circulation* 1988; **77:** 721.

Large-volume paracentesis in nonedematous patients with tense ascites; its effect on intravascular volume. Pinto PC, Amerian J, Reynolds TB. *Hepatology* 1988; **8:** 207.

Determinants of left ventricular function one year after cardiac transplantation. Reid CJ, Yacoub MH. *British Heart Journal* 1988; **59:** 397.

Calcium antagonist receptors. Reynolds IJ, Snyder SH. In: Narahashi T ed. *Ion Channels, Vol. 1.* New York: Plenum Publishing, 1988: 213.

Vasoconstrictor role of vasopressin and angiotensin in experimental aortic stenosis in the rat. Riegger GAJ, Wolf P, Kochsiek K. *Journal of Cardiovascular Pharmacology* 1988; **11:** 538.

Mental stress and the induction of silent myocardial ischemia in patients with coronary artery disease. Rozanski A, Bairey CN *et al. New England Journal of Medicine* 1988; **318:** 1005.

Dyspnea—heart or lungs? Staats BA. *International Journal of Cardiology* 1988; **19:** 13.

Hypertension, non-insulin-dependent diabetes, and intracellular sodium metabolism. Trevisan M, Vaccaro O *et al. Hypertension* 1988; **11:** 264.

Effect of lower body positive pressure on BP, plasma ANF concentration, and electrolytes in the healthy and in cardiac transplant recipients. Wilkins MR, Gammage MD *et al. Cardiovascular Research* 1988; **22:** 231.

Dynamic measurement of human capillary blood pressure. Williams SA, Wasserman S *et al. Clinical Science* 1988; **74:** 507.

Treatment and medication

Atrial fibrillation: natural history, complications, and management. Alpert JS, Petersen P, Godtfredsen J. *Annual Review of Medicine* 1988; **39:** 41.

Alprazolam in the treatment of cardiology patients with atypical chest pain and panic disorder. Beitman BD, Basha IM *et al. Journal of Clinical Psychopharmacology* 1988; **8:** 127.

Neurohumoral profile in congestive heart failure: response to beta-blockade. Binkley PF, Lewe R *et al. Journal of Laboratory and Clinical Medicine* 1988; **111:** 393.

Assessment of the use of transfusion therapy perioperatively in patients with sickle cell hemoglobinopathies. Bischoff RJ, Williamson A III *et al. Annals of Surgery* 1988; **207:** 434.

Beneficial actions of antagonism of peptide leukotrienes in hemorrhagic shock. Bitterman H, Smith BA, Lefer AM. *Circulatory Shock* 1988; **24:** 159.

Regional vascular effects of serotonin and ketanserin in young, healthy subjects. Blauw GJ, Van Brummelen P *et al. Hypertension* 1988; **11:** 256.

Reduction in fatal pulmonary embolism and venous thrombosis by perioperative administration of subcutaneous heparin: review of results in general, orthopedic and urologic surgery. Collins R, Scrimgeour A *et al. New England Journal of Medicine* 1988; **318:** 1162.

Ventilation with the esophageal tracheal combitube in cardiopulmonary resuscitation—promptness and effectiveness. Frass M, Frenzer R *et al. Chest* 1988; **93:** 781.

Characteristics and regulatory mechanisms of the amiloride-blockable Na$^+$ channel. Garty H, Benos DJ. *Physiological Reviews* 1988; **68:** 309.

The effect of oxygen free radical scavengers on the recovery of regional myocardial function after acute coronary occlusion and surgical reperfusion. Gharagozloo F, Melendez FJ *et al. Journal of Thoracic and Cardiovascular Surgery* 1988; **95:** 631.

Modulating the beta-receptor in congestive heart failure. Goldsmith SR. *Journal of Laboratory and Clinical Medicine* 1988; **111:** 363.

Ventricular tachycardia and sudden death in myotonic dystrophy. Hiromasa S, Ikeda T *et al. American Heart Journal* 1988; **115:** 914.

Intravenous lorcainide for symptomatic ventricular tachyarrhythmias: comparison with lidocaine and oral lorcainide. Hohnloser SH, Podrid PJ, Lown B. *American Heart Journal* 1988; **115:** 824.

Hypertension, antihypertensive treatment, and sudden coronary death: the Framingham study. Kannel WB, Cupples LA *et al. Hypertension* 1988; **11** Part 2 (Suppl.): 11–45.

Cardiac failure and sudden death in the Framingham study. Kannel WB, Plehn JF, Cupples LA. *American Heart Journal* 1988; **115:** 869.

Myocardial infarction: the first 24 hours. Lipkin DP, Reid CJ. *British Medical Journal* 1988; **296:** 947.

Prognosis of patients receiving intensive care for lifethreatening medical complications of haematological malignancy. Lloyd-Thomas AR, Wright I *et al. British Medical Journal* 1988; **295:** 1025.

The effects of hespan on serum and lymphatic albumin, globulin, and coagulant protein. Lucas CE, Denis R *et al. Annals of Surgery* 1988; **207:** 416.

The immature and the mature myocardium—responses to multi-dose crystalloid cardioplegia. Magovern JA, Pae WE *et al. Journal of Thoracic and Cardiovascular Surgery* 1988; **95:** 618.

The potential for added benefits with beta-blockers and calcium antagonists in treating cardiovascular disorders. Nayler WG. *Drugs* 1988; **35** (Suppl. 4): 1.

Hypertrophic cardiomyopathy and sudden death. Nicod P, Polikar R, Peterson KL. *New England Journal of Medicine* 1988; **318:** 1255.

Effects of calcium antagonists on serotonin and noradrenaline venoconstriction in humans. Panconesi A, Franchi G *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 442.

Diagnosis and management of early postoperative complications in open heart surgery. Peuhkurinen KJ, Korhonen U. *Annals of Clinical Research* 1987; **19:** 365.

The effect of temperature and hematocrit level of oxygenated cardioplegic solutions on myocardial preservation. Rousou JA, Engelman RM *et al. Journal of Thoracic and Cardiovascular Surgery* 1988; **95:** 625.

Overinflation of pneumatic antishock garments in the elderly. Savino JA, Jabbour I *et al. American Journal of Surgery* 1988; **155:** 572.

Calcium antagonists, a new class of antihypertensive agents. Schwartz J. *Fundamental and Clinical Pharmacology* 1988; **2:** 103.

Esmolol—safety and efficacy in postoperative cardiothoracic patients with supraventricular tachyarrhythmias. Schwartz M, Michelson EL *et al. Chest* 1988; **93:** 705.

Class II antiarrhythmic agents. Upward JW, Waller DG, George CF. *Pharmacology and Therapeutics* 1988; **37:** 81.

Rapid enzyme release from acutely infarcted myocardium after early thrombolytic therapy: washout or reperfusion damage? Van Der Laarse A, Van Der Wall EE *et al. American Heart Journal* 1988; **115:** 711.

Appropriate electrophysiologic study and treatment of patients with the Wolff-Parkinson-White syndrome. Waldo AL, Akhtar M *et al. Journal of the American College of Cardiology* 1988; **11:** 1124.

Drug therapy: encainide. Woosley RL, Wood AJJ, Roden DM. *New England Journal of Medicine* 1988; **318:** 1107.

Effect of intravenous nitrates on mortality in acute myocardial infarction: an overview of the randomised trials. Yusuf S, Collins R *et al. Lancet* 1988; **I:** 1088.

Respiration

Physiology

Effects of expiratory flow resistance on inspiratory work of breathing. Banner MJ, Downs JB *et al. Chest* 1988; **93:** 795.

Neuropeptides in human airways. Barnes PJ. In: Armour CL, Black JL, eds. *Mechanisms in asthma.* New York: A R Liss, 1988: 111.

Effect of hyperoxia and hypoxia on exercise-induced breathlessness in normal subjects. Chronos N, Adams L, Guz A. *Clinical Science* 1988; **74:** 531.

Fatigue of the inspiratory muscle pump in humans: an isoflow approach. Clanton TL, Ameredes BT. *Journal of Applied Physiology* 1988; **64:** 1693.

Cardiac output and O_2 consumption during inspiratory threshold loaded breathing. Coast JR, Jensen RA *et al. Journal of Applied Physiology* 1988; **64:** 1624.

Effects of upper airway anesthesia on pharyngeal patency during sleep. De Weese EL, Sullivan TY. *Journal of Applied Physiology* 1988; **64:** 1346.

Role of cooling and drying in hyperventilation induced asthma. Farley RD, Albazzaz MK, Patel KR. *Thorax* 1988; **43:** 289.

Computer analysis of oxygen consumption and minute ventilation for the detection of the lactate threshold. Hossack KF, Eldridge JE *et al. Cardiology* 1988; **75:** 123.

Pulmonary edema after Escherichia-Coli peritonitis correlates with thiobarbituric-acid-reactive materials in bronchoalveolar lavage fluid. Ishizaka A, Stephens KE *et al. American Review of Respiratory Disease* 1988; **137:** 783.

Variability of the breathing pattern before and after extubation. Krieger BP, Chediak A *et al. Chest* 1988; **93:** 767.

Low dose aminophylline selectively increases upper airway motor activity in normals. Lahive KC, Weiss JW, Weinberger SE. *Respiration Physiology* 1988; **72:** 151.

Assessment of diaphragm weakness. Mierjedrzejowicz A, Brophy C *et al. American Review of Respiratory Disease* 1988; **137:** 877.

Cytochrome-P450 in nitrogen metabolism. Miwa GT, Walsh JS. In: Cho AK, Lindeke B, eds. *Biotransformation of organic nitrogen compounds.* Basel: S. Karger, 1988: 27.

Nitrogen oxidation in toxicity. Prough RA, Erikson JM, Wiebkin P. In: Cho AK, Lindeke B, eds. *Biotransformation of organic nitrogen compounds.* Basel: S. Karger, 1988: 161.

Diaphragmatic elevation in stroke. Santamaria J, Ruiz C. *European Neurology* 1988; **28:** 81.

The effect of human heart-lung transplantation upon breathing at rest and during sleep. Shea SA, Horner RL *et al. Respiration Physiology* 1988; **72:** 131.

Airflow and normal lung sounds. Shykoff BE, Ploysongsang Y, Chang HK. *American Review of Respiratory Disease* 1988; **137:** 872.

Hypoxemia during sleep in Duchenne muscular dystrophy. Smith PEM, Calverley PMA, Edwards RH. *American Review of Respiratory Disease* 1988; **137:** 884.

Respiratory function measurements including an assessment of the area under the MEFC curve as a new parameter in chronic bronchitic patients. Struthers AD, Addis GJ. *European Journal of Clinical Pharmacology* 1988; **34:** 277.

An acute reduction in the fraction of inspired oxygen increases airway constriction in infants with chronic lung disease. Teague WG, Pian MS *et al. American Review of Respiratory Disease* 1988; **137:** 861.

The pulmonary surfactant system: biochemical aspects and functional significance. Van Golde LM, Batenburg JJ, Robertson B. *Physiological Reviews* 1988; **68:** 374.

Treatment and medication

Effect of normobaric hyperoxia on airways of normal subjects. Beckett WS, Wong ND. *Journal of Applied Physiology* 1988; **64:** 1683.

Effects of fenoterol on oxygen transport in patients with chronic airflow obstruction. Carlone S, Angelici E *et al. Chest* 1988; **93:** 790.

Ventilatory response to sustained hypoxia after pretreatment with aminophylline. Easton PA, Anthonisen NR. *Journal of Applied Physiology* 1988; **64:** 1445.

Use of oxygen therapy for adult patients outside the critical care areas of a university hospital. Fitzgerald JM, Baynham R, Powles ACP. *Lancet* 1988; **1:** 981.

Chest physiotherapy—evaluation by transcutaneous blood gas monitoring. Herala M, Gislason T. *Chest* 1988; **93:** 800.

Ibuprofen reduces the lung lymph flow changes associated with inhalation injury. Kimura R, Traber L *et al. Circulatory Shock* 1988; **24:** 183.

Diaphragm strength in patients with recent hemidiaphragm paralysis. Laroche CM, Mier AK *et al. Thorax* 1988; **43:** 170.

Prediction of oxygenation during sleep in patients with chronic obstructive lung disease. McKeon JL, Muree-Allen K, Saunders NA. *Thorax* 1988; **43:** 312.

Diaphragm pacing. Moxham J, Potter D. *Thorax* 1988; **43:** 161.

Effect of positive end-expiratory pressure on alveolar capillary perfusion. Nieman GF, Paskanik AM, Bredenberg CE. *Journal of Thoracic and Cardiovascular Surgery* 1988; **95:** 712.

Chest physiotherapy—time for reappraisal. Sutton PP. *British Journal of Diseases of the Chest* 1988; **82:** 127.

Central nervous system

Physiology

The opioid system and temperature regulation. Adler MW, Geller EB *et al. Annual Review of Pharmacology and toxicology* 1988; **28:** 429.

Effect of posttraumatic hypoventilation on cerebral energy metabolism. Andersen BJ, Unterberg AW *et al. Journal of Neurosurgery* 1988; **68:** 601.

Cholinergic false transmitters: physiological and biochemical actions in central and peripheral systems. Aronstam RS, Marshall DC, Buccafusco J. *Neuropharmacology* 1988; **27:** 217.

In vivo assessment of neurotransmitter biochemistry in humans. Barrio JR, Huang S-C, Phelps ME. *Annual Review of Pharmacology and Toxicology* 1988; **28:** 213.

Precursors of cholinergic false transmitters: central effects on blood pressure and direct interactions with cholinergic receptors. Buccafusco JJ, Aronstam RS. *Neuropharmacology* 1988; **27:** 227.

Secondary dystonia. Calne DB, Lang AE. In: Fahn S, Marsden CD, Calne DB, eds. *Dystonia 2.* New York: Raven Press 1988: 9.

Blood-brain barrier and atrial natriuretic factor. Chabrier PE, Roubert P *et al. Canadian Journal of Physiology and Pharmacology* 1988, **66:** 276.

Central blood volume and blood pressure in conscious primates. Cornish KG, Gilmore JP, McCulloch T. *American Journal of Physiology* 1988; **254:** H693.

Concept and classification of dystonia. Fahn S. In: Fahn S, Marsden CD, Calne DB, eds. *Dystonia 2*. New York: Raven Press, 1988: 1.

The sleep hypopnea syndrome. Gould GA, Whyte KF *et al. American Review of Respiratory Disease* 1988; **137:** 895.

Hypothalamic pathology in the neuroleptic malignant syndrome. Horn E, Lach B *et al. American Journal of Psychiatry* 1988; **145:** 617.

Certral interaction of the brain ANP system and the brain renin-angiotensin system in ANP secretion from heart—evidence for possible brain-heart axis. Itoh H, Nakao K *et al. Canadian Journal of Physiology and Pharmacology* 1988; **66:** 255.

Influences from laryngeal afferents on expiratory bulbospinal neurons and motoneurons. Jodkowski JS, Berger AJ. *Journal of Applied Physiology* 1988; **64:** 1337.

Steroid hormones and neurotrophism: relationship to nerve injury. Jones KJ. *Metabolic Brain Disease* 1988; **3:** 1.

Autonomic dysfunction in Lambert-Eaton myasthenic syndrome. Khurana RK, Koski CL, Mayer RF. *Journal of the neurological sciences* 1988; **85:** 77.

Recent advances in blood-brain barrier transport. Pardridge WM. *Annual Review of Pharmacology and Toxicology* 1988; **28:** 25.

Body fat and the activity of the autonomic nervous system. Peterson HR, Rothschild M *et al. New England Journal of Medicine* 1988; **318:** 1077.

Acetylcholinesterase and butyrylcholinesterase in cerebrospinal fluid from patients with dystonia. Ruberg M, Villageois A *et al.* In: Fahn S, Marsden CD, Calne DB, eds. *Dystonia 2*. New York: Raven Press 1988: 211.

Cerebral blood flow changes during sodium-lactate-induced panic attacks. Stewart RS, Devous MD *et al. American Journal of Psychiatry* 1988; **145:** 442.

Alpha-1 adrenergic receptors in the central nervous system. Szabadi E, Bradshaw CM. In: Ruffolo RR, ed. *Alpha-1 adrenergic receptors*. Clifton: Human Press, 1987: 405.

Role of alpha-adrenoceptors in the control of the cerebral blood flow response to hypoxia. Weiss HR, Buchweitz-Milton E. *European Journal of Pharmacology* 1988; **148:** 107.

Cerebellar dysfunction in patients with bronchogenic carcinoma: immunological investigations. Wessel K, Budde-Steffen C *et al. Journal of Neurology* 1988; **235:** 297.

Cerebellar dysfunction in patients with bronchogenic carcinoma: clinical and posturographic findings. Wessel K, Diener HC *et al. Journal of Neurology* 1988; **235:** 290.

Treatment and medication

Heparin-induced thrombocytopenia and thrombosis in ischemic stroke. Atkinson JLD, Sundt TM *et al. Mayo Clinic Proceedings* 1988; **63:** 353.

A new endogenous anxiolytic agent: L-pyroglutamic acid. Beni M, Pellegrini-Giampietro D, Moroni F. *Fundamental and Clinical Pharmacology* 1988; **2:** 77.

Head injury and hemorrhagic shock—studies of the blood brain barrier and intracranial pressure after resuscitation with saline solution and dextran-40. Gunnar W, Jonasson O *et al. Surgery* 1988; **103:** 398.

Neuroleptics and neuroendocrine function. Gunnet JW, Moore KE. *Annual Review of Pharmacology and Toxicology* 1988; **28:** 347.

Catecholamine-containing grafts in Parkinsonism: past and present. Hoffer BJ, Granholm A-N *et al. Clinical Research* 1988; **36:** 189.

Drug treatment of stroke: current status and future prospects. Sila CA, Furlan AJ. *Drugs* 1988; **35:** 468.

Endocrine and metabolic

Physiology

Bradykinin analogues: differential agonist and antagonist activities suggesting multiple receptors. Braas KM, Manning DC *et al. British Journal of Pharmacology* 1988; **94:** 3.

Beta-cell deficiency, insulin resistance, or both? Cahill GF. *New England Journal of Medicine* 1988; **318:** 1268.

Pulsatile ACTH secretion: variation with time of day and relationship to cortisol. Carnes M, Kalin NH *et al. Peptides* 1988; **9:** 325.

Neuroendocrine findings in anxiety disorders. Curtis GC, Glitz DA. *Endocrinology and Metabolism Clinics of North America* 1988; **17:** 131.

Suppression of AVP release by drinking despite hypertonicity during and after gestation. Davison JM, Shiells EA *et al. American Journal of Physiology* 1988; **254:** F588.

Immunoreactive vasopressin and oxytocin in hypothalamo-hypophysial portal blood of rat: effect of adrenalectomy and dexamethasone. Eckland DJA, Todd K, Lightman SL. *Journal of Endocrinology* 1988; **117:** 27.

Suction chamber protection for endoscope biopsy-channel valves. Firth JD, Raine AEG, Ledingham JGG. *Lancet* 1988; **1:** 1033.

Effects of hemorrhage and opiate antagonists on adrenal release of neuropeptides in cats. Gaumann DM, Yaksh TL. *Peptides* 1988; **9:** 393.

The relevance of corticotropin releasing hormone to normal physiology and to pathophysiologic alterations in hypothalamic pituitary adrenal function. Gold PW, Whitfield HJ *et al.* In: Schatzberg AF, Nemeroff CB, eds. *Hypothalamic-pituitary-adrenal Axis*. New York: Raven Press, 1988: 101.

Prolactin and neuroleptic drugs. Green AI, Brown WA. *Endocrinology and Metabolism Clinics of North America* 1988; **17:** 213.

Opioid-mediated inhibition of oxytocin during insulin-induced hypoglycemic stimulation of vasopressin in man. Haddock JA, Dunne MJ, Lightman SL. *Acta Endocrinologica* 1988; **118:** 77.

Differences in renal metabolism of insulin and cytochrome c. Herrman J, Simmons RE *et al. American Journal of Physiology* 1988; **254:** E419.

Vasopressin and oxytocin neurohypophysial content under conditions of beta-adrenergic blockade in euhydrated and dehydrated rats—further studies. Janus J. Guzek JW. *Experimental and Clinical Endocrinology* 1988; **91:** 78.

Effects of plasma volume and oxmolality on secretion of atrial natriuretic peptide and vasopressin in man. Kamoi K, Sato F *et al. Acta Endocrinologica* 1988; **118:** 51.

Central effects of catecholamine antagonists on angiotensin-induced vasopressin secretion in conscious rats. Karakida T, Koike M, Hama H. *Acta Endocrinologica* 1988; **118:** 82.

The endocrinology of extrapyramidal system disorders. Kirkpatrick B, Tamminga CA. *Endocrinology and metabolism clinics of North America* 1988; **17:** 159.

Intermediary metabolism, insulin sensitivity and insulin receptor status under therapy with insulin injections and continuous subcutaneous insulin infusion. Marshall SM, Taylor R *et al. Acta Endocrinologica* 1988; **117:** 417.

Effects of vasopressin on the human non-pregnant uterus: studies with analogues of different vasopressor potencies. Melin P, Trojnar J *et al. European Journal of Pharmacology* 1988; **148:** 93.

Effect of lung resection on blood lactate threshold in lung cancer patients. Miyoshi S, Nakahara K *et al. European Journal of Applied Physiology and Occupational Physiology* 1988; **57:** 388.

Hyperglycemic hyperosmolar nonketotic dehydration in relation to blood ketone body ratio in partially hepatectomized rabbits. Nakatani T, Yasuda K, Ozawa K. *American Journal of Surgery* 1988; **155:** 559.

Osmoreceptor mechanism for oxytocin release in the rat. Negoro H, Higuchi T *et al. Japanese Journal of Physiology* 1988; **38:** 19.

Impaired pulsatile secretion of insulin in relatives of patients with non-insulin dependent diabetes. O'Rahilly S, Turner RC, Matthews DR. *New England Journal of Medicine* 1988; **318:** 1226.

Abnormal patterns of insulin secretion in non-insulin-dependent diabetes mellitus. Polonsky SK, Given BD *et al. New England Journal of Medicine* 1988; **318:** 1231.

The P90 as a clinically relevant landmark on the oxyhemoglobin dissociation curve. Rebuck AS, Chapman KR. *American Review of Respiratory Disease* 1988; **137:** 962.

Ontogeny of corticotropin-releasing factor and arginine vasopressin in the rat. Rundle SE, Funder JW. *Neuroendocrinology* 1988; **47:** 374.

The hypothalamic-pituitary-adrenocortical axis in major depression. Stokes PE, Sikes CR. *Endocrinology and Metabolism Clinics of North America* 1988; **17:** 1.

Predicting insulin-dependent diabetes. Tam AC, Thomas JN *et al. Lancet* 1988; **1:** 845.

Insulin clearance from plasma in type 1 (insulin-dependent) diabetic patients: influence of glycaemic level. Thorsteinsson B, Fugleberg S, Binder C. *Pharmacology and Toxicology* 1988; **62:** 206.

Osmoregulation of thirst and vasopressin during normal menstrual cycle. Vokes TJ, Weiss NM *et al. American Journal of Physiology* 1988; **254:** R641.

Motor drive and metabolic responses during repeated submaximal contractions in humans. Vollestad NK, Sejersted OM *et al. Journal of Applied Physiology* 1988; **64:** 1421.

Treatment and medication

Management of early postoperative diabetes insipidus with parenteral desmopressin. Chanson P, Jedynak CP, Czernichow P. *Acta Endocrinologica* 1988; **117:** 513.

Diabetic cardiopathy: Is it a real entity? Crepaldi G, Nosadini R. *Diabetes/Metabolism Reviews* 1988; **4:** 273.

Reduced in non-insulin-dependent diabetes. Ferner RE, Rawlins MD, Alberti KGMM. *Quarterly Journal of Medicine* 1988; **66:** 137.

Pathogenesis and prevention of diabetic neuropathy. Greene DA, Lattimer SA, Sima AAF. *Diabetes/Metabolism Reviews* 1988; **4:** 201.

Treatment of the diabetic patient with end-stage renal failure. Jacobson SH, Fryd D *et al. Diabetes/Metabolism Reviews* 1988; **4:** 191.

Management of diabetic renal involvement and disease. Mogensen CE. *Lancet* 1988; **1:** 867.

Why dexamethasone resistance—2 possible neuroendocrine mechanisms. Sapolsky RM, McEwen BS. In: Schatzberg AF, Nemeroff CB, eds. *Hypothalamic-pituitary-adrenal axis.* New York: Raven Press, 1988: 155.

The effects of atrial natriuretic peptide and amiloride on renal haemodynamics and the renal kallikrein-kinin system. Seino M, Abe K *et al. Journal of Hypertension* 1988; **6:** 321.

Renal actions of calcium antagonists. Sterzel RB. *Journal of Cardiovascular Pharmacology* 1987; **10** (Suppl. 10): S17.

Kinetics of prednisolone and endogenous cortisol suppression in the elderly. Stuck AE, Frey BM, Frey F. *Clinical Pharmacology and Therapeutics* 1988; **43:** 354.

Insulin for the non-insulin dependent? Taylor R. *British Medical Journal* 1988; **296:** 1015.

Clinical aspects of diabetic neuropathies. Vinik A, Mitchelle B. *Diabetes/Metabolism Reviews* 1988; **4:** 223.

Postprandial glycaemic effects of a long-acting somatostatin analogue (octreotide) in non-insulin dependent diabetes mellitus. Williams G, Guessl HS *et al. Hormone and Metabolic Research* 1988; **20** 168.

Pain

Physiology

Substance P in CSF of patients with chronic pain syndromes. Almay BGL, Johansson F *et al. Pain* 1988; **33:** 3.

Glucocorticoid and pain regulation. Calignano A, Persico P, Sorrentino L. *Pharmacological Research Communications* 1988; **20:** 225.

Pain intensity measurements in patients with acute pain receiving afferent stimulation. Ekblom A, Hansson P. *Journal of Neurology, Neurosurgery and Psychiatry* 1988; **51:** 481.

Peripheral mechanisms of somatic pain. Raja SN, Meyer RA, Campbell JN. *Anesthesiology* 1988; **68:** 571.

Treatment and medication

Lack of analgesic effect of opioids on neuropathic and idiopathic forms of pain. Arner S, Meyerson BA. *Pain* 1988; **33:** 11.

Control of pain in the perioperative period. Hull CJ. *British Medical Bulletin* 1988; **44:** 341.

Continuous narcotic infusion with patient-controlled analgesia for chronic cancer pain in outpatients. Kerr IG, Sone M *et al. Annals of Internal Medicine* 1988; **108:** 554.

Acute postsurgical pain in orthopedic surgery: a comparison of sodium naproxen and pentazocine in several analgesic protocols. Lari S, Coli A *et al. Current Therapeutic Research* 1988; **43:** 689.

Association of pain relief with drug side effects in postherpetic neuralgia: A single-dose study of clonidine, codeine, ibuprofen, and placebo. Max MB, Schafer SC *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 363.

Other

Physiology

Electrical and mechanical activity in the human lower esophageal sphincter during diaphragmatic contraction. Mittal RK, Rochester DF, McCallum RW. *Journal of Clinical Investigation* 1988; **81:** 1182.

Functional mechanisms of temperature regulation, adaptation and fever: complementary system theoretical and experimental evidence. Werner J. *Pharmacology and Therapeutics* 1988; **37:** 1.

Anaesthesia, 1988, Volume 43, page 821

Hazard notice

Syringe pumps: uncontrolled infusion (HC(Hazard)(88)9)

Uncontrolled infusion or 'free flow' from a syringe pump may occur if either the plunger or the barrel of the syringe is not attached securely to the appropriate part of the pump and the pump is situated at a significant height above the infusion site. The significant height is apparently a mere 45 cm.

It is important that both the plunger and the barrel of the syringe are secured to the pump. If no clamp for the plunger is available, the infusion pump can still be used provided that it is not placed higher than the infusion site. It is also important that the syringes which are recommended by the manufacturer for their particular pump are used.

Stop Press

22–23 September, 1988. Oxford. *Obstetric Anaesthetists Association and Society for Obstetric Anaesthesia and Perinatology Meeting.* *Information*: Dr L.E.S. Carrie or Dr C.E. Blogg, Nuffield Department of Anaesthetics, John Radcliffe Hospital, Headington, Oxford OX3 9DU.

Course in Anaesthesia

FFARCS Part I

WREXHAM
Wrexham Maelor Hospital, 22–24 September 1988
Wrexham,
Clwyd LL12 7TD.

The Anaesthetic Department
Wrexham Maelor Hospital,
Wrexham, Clwyd LL12 7TD.

Anaesthesia, 1988, Volume 43, page 822

Errata

Anaesthesia, 1988, Volume 43, page 514

Propofol infusions for status epilepticus

H. F. YANNY AND D. CHRISTMAS

The middle of the second paragraph of this letter should read:

Tracheal intubation with an 8.0 mm cuffed Portex profile tube was performed on admission to the Intensive Therapy Unit, after propofol 120 mg and suxamethonium 100 mg.

Towards the end of the paragraph it should read:

A propofol infusion was commenced at a rate of 6 mg/kg/hour, *and no further seizures were observed on the CFAM trace for the next 24 hours.*

Anaesthesia, 1988, Volume 43, pages 437–438

Successful difficult intubation

J. F. KIDD, A. DYSON AND I. P. LATTO

In the Results section, the initial views at laryngoscopy Grade 1 should be 83 patients.

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The Committee on Enzymes of the Scandinavian Society for Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gamma-glutamyltransferase in blood. *Scandinavian Journal of Clinical Laboratory Investigation* 1976; **36:** 119–25.
Anonymous. Epidemiology for primary health care. *International Journal of Epidemiology* 1976; **5:** 224–5.

BOOKS AND OTHER MONOGRAPHS
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OSLER AG. *Complement: mechanisms and functions.* New York: Prentice-Hall, 1976.

Corporate authors
American Medical Association Department of Drugs. AMA drug evaluations, 3rd edn. New York: Publishing Sciences Group, 1977.

Editor, compiler, chairman as author
RHODES AJ, VAN ROOYEN CE, *comps. Textbook of virology: for students and practitioners of medicine and other health sciences,* 5th edn. Baltimore: The Williams & Wilkins Co., 1968.

Chapter in book
WEINSTEIN L, SWARTZ MN. Pathogenic properties of invading micro-organisms. In: SODEMAN WA Jr, SODEMAN WA, eds. *Pathologic physiology: mechanisms of disease.* Philadelphia: W.B. Saunders, 1974: 457–72.

Agency publication
National Center for Health Statistics. Acute conditions: incidence and associated disability, United States, July 1968—June 1969. Rockville, MD: National Center for Health Statistics, 1972. (*Vital and health statistics, Series* **10:** Data from the National Health Survey, No. 69) [DHEW publication No. (HSM) 72–1036].

OTHER ARTICLES
Newspaper article
SHAFFER RA. Advances in chemistry are starting to unlock mysteries of the brain: discoveries could help to cure alcoholism and insomnia, explain mental illness. How the messengers work. *Wall Street Journal* 1977 Aug 12: 1(col 1), 10(col 1).

Magazine article
ROUECHE B. Annals of medicine: the Santa Claus culture. *The New Yorker* 1971 Sept 4: 66–81.

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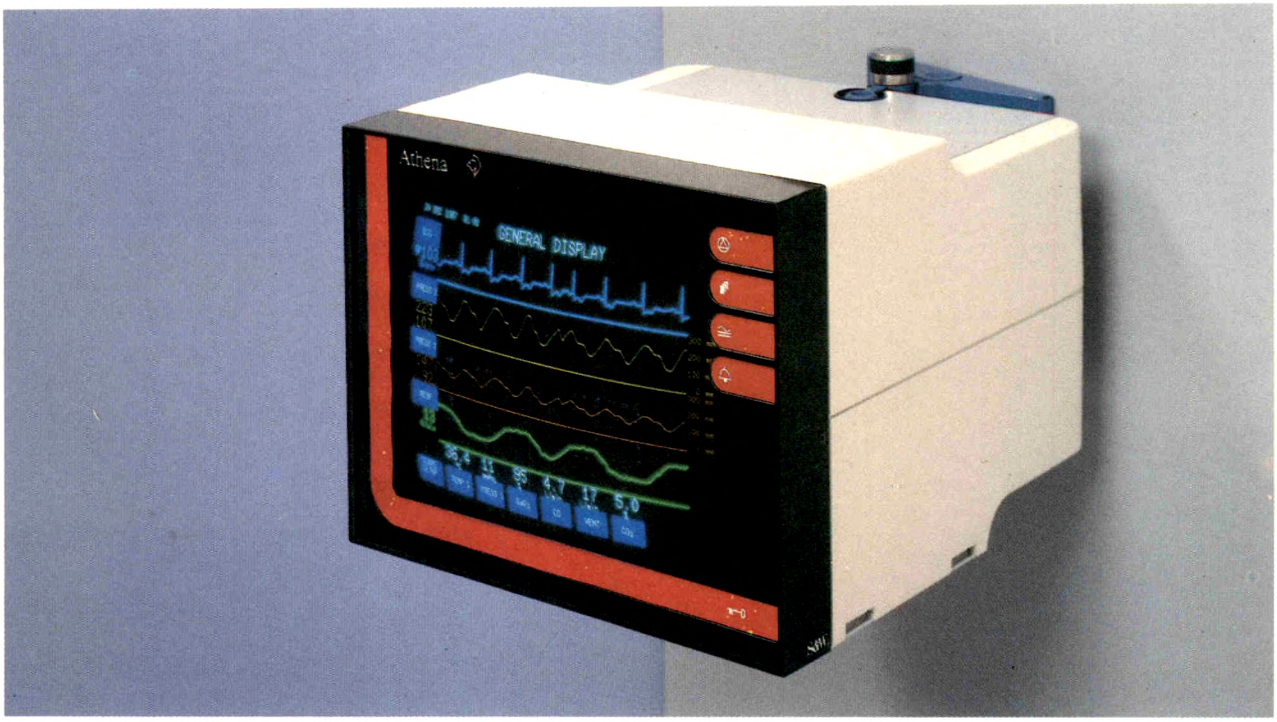

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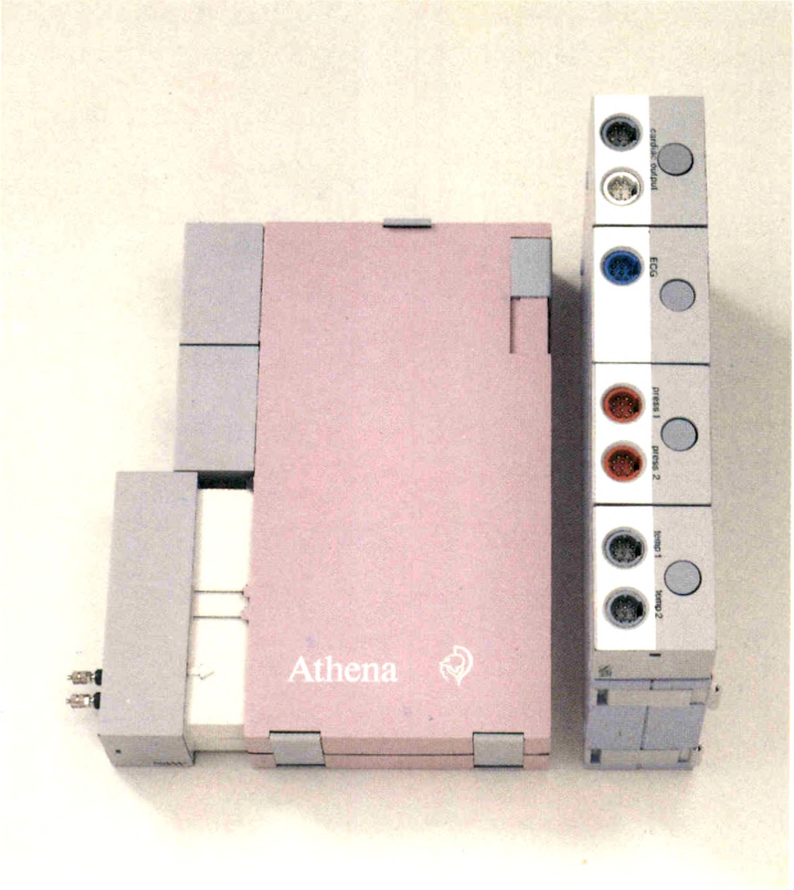

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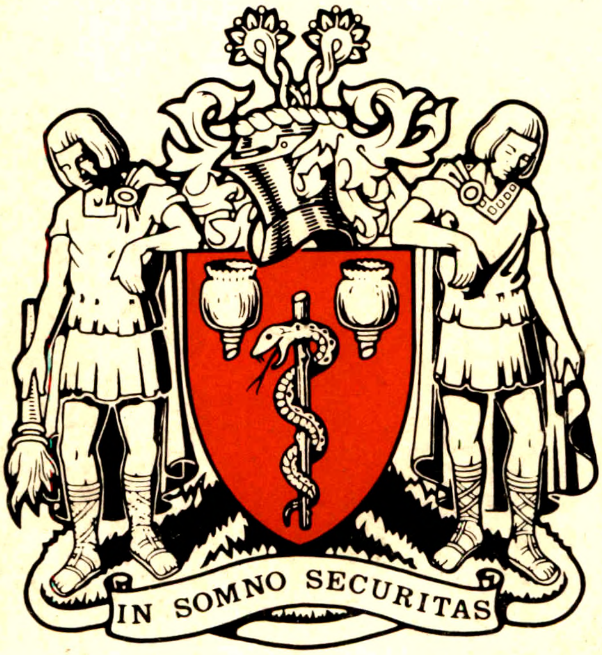

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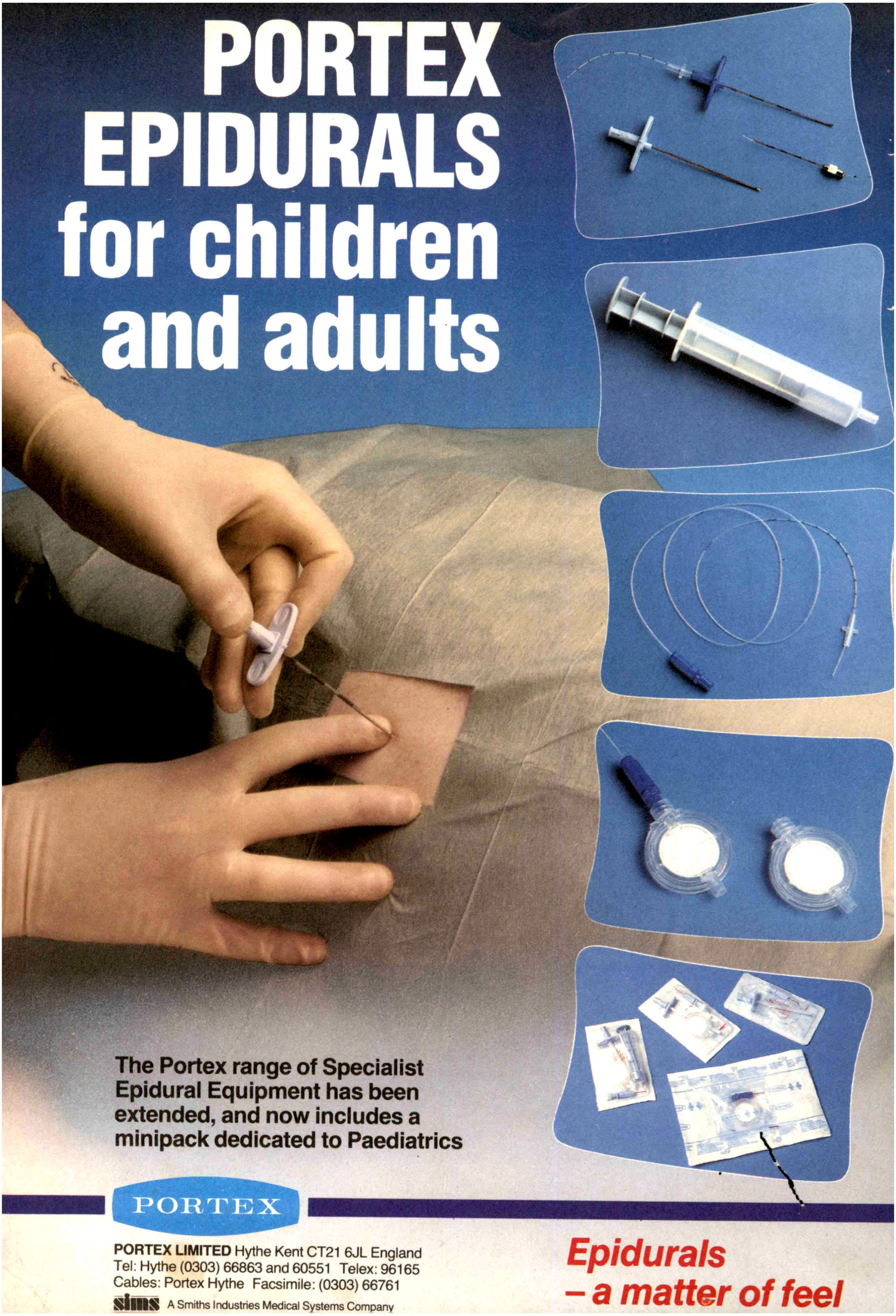

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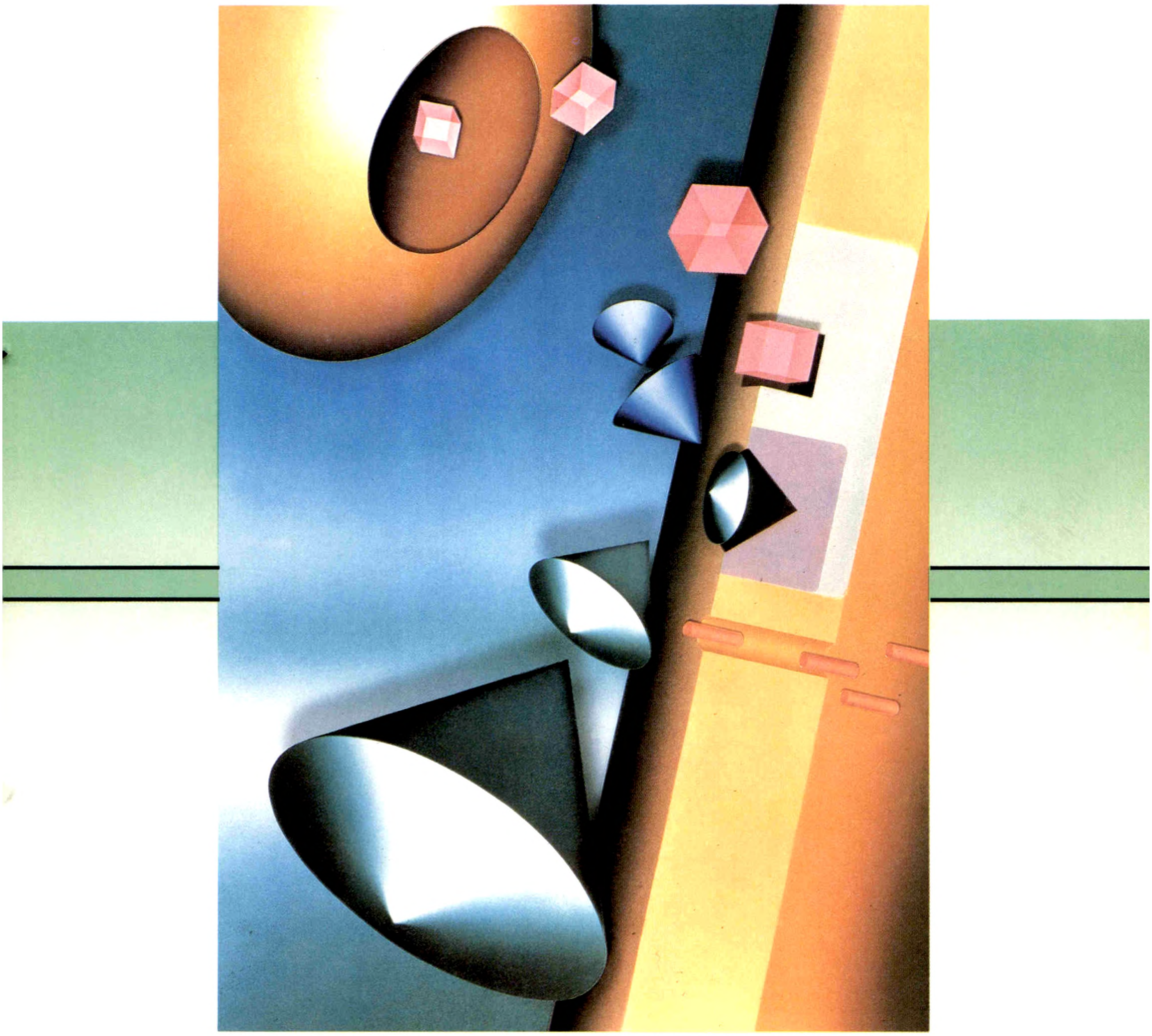

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chronically exposed to high doses of benzodiazepines. Should unexpected signs of overstimulation occur, an individually titrated dose of diazepam or midazolam should be given by slow intravenous injection. Any neuromuscular blockade should be cleared before Anexate is administered. Complete arousal may be inadvisable in anxious patients, particularly those with coronary artery disease, or in those experiencing pain. Patients should not drive or operate machinery for at least 24 hours after administration. **Side-effects and Adverse Reactions** Anexate is generally well tolerated. Nausea and/or vomiting and flushing may occur. Rapid awakening may result in agitation or anxiety. Seizures have been reported rarely, particularly in epileptics. Transient increases in heart rate and blood pressure may occur on awakening in intensive care patients. **Legal Category** POM. **Availability** Hospitals, clinics or retail pharmacies. **Presentation** Ampoules containing 500 micrograms flumazenil in 5ml, in packs of 5. **Basic NHS Cost** £16.32 per ampoule 500 micrograms/5ml. **Product Licence Number** 0031/0228. **Product Licence Holder** Roche Products Limited, PO Box 8, Welwyn Garden City, Hertfordshire AL7 3AY. Full prescribing information is available on request. Anexate is a trade mark. Date of preparation April 1988.

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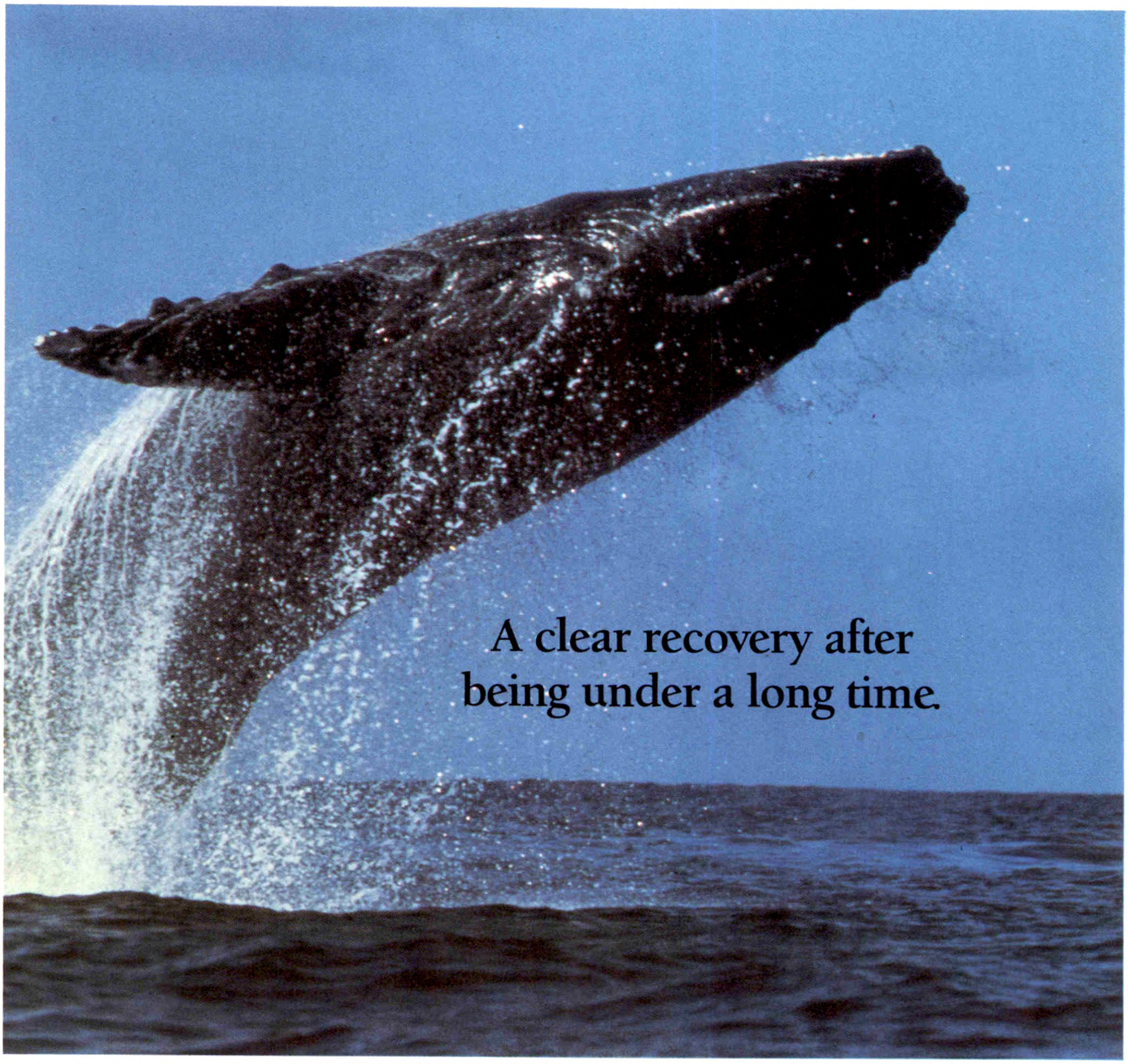

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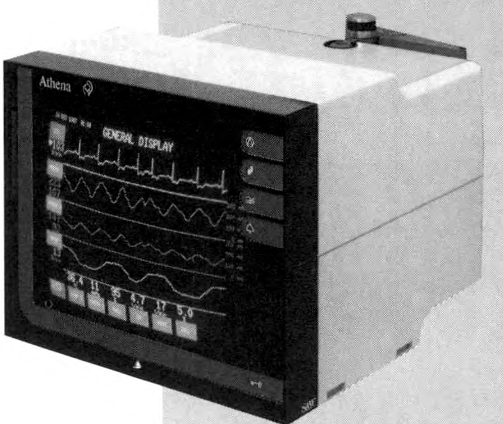

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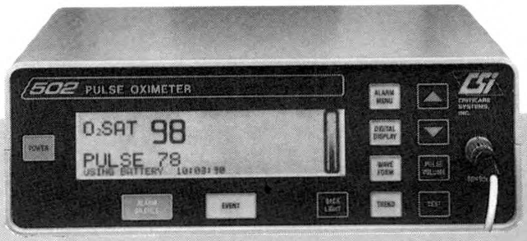

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Datex took the lead in airway gas monitoring – and we are still a step ahead...

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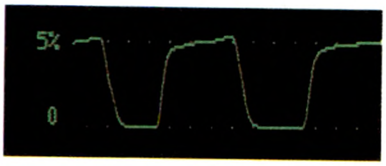
Throughout its history, Datex has been guided by progressive anaesthetists with a firm belief in the value of capnometry for intra-operative monitoring.

Today, Datex is at the forefront of technological advances in anaesthesia monitoring, as it has been ever since the introduction of the first compact capnometer in 1975.

1943 Luft developed the principle of capnography. For several decades CO_2 monitoring was restricted to research, since it demanded a delicate and bulky measurement system.



Continuous display of the CO_2 waveform permits real-time diagnosis of abnormalities and complications.

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1975 Datex introduced the world's first compact capnometer, bringing the routine monitoring of CO_2 within reach of all operating theatres.

The heart of Datex's revolutionary CD-101 capnometer was a new miniature infra-red photometer. The fact that our first capnometers are still in routine clinical use today underlines the inherent reliability of Datex measurement technology.

The year 1975 also saw another milestone in the history of CO_2 monitoring, sixteen years of research into the diagnostic value of the CO_2 waveform culminated in the publication of "An Atlas of Capnography" by B. Smalhout and Z. Kalenda.

1980 Datex introduced the Normocap^R capnometer with the patented 'sidestream' water trap, further improving the measurement reliability and ease-of-use.

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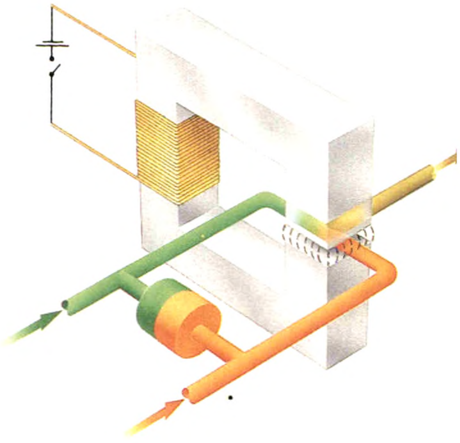
By 1982, the Datex Normocap^R had already become the most popular stand-alone capnometer ever manufactured. And today, essentially unchanged, it is still in demand for its reliability and simplicity.

1983 Building on expertise acquired in CO_2 monitoring technology, Datex developed the Normac™ anaesthetic agents monitor, the first to use infra-red photometry.

Several innovations in infrared photometry resulted in a sensor that was accurate and reliable enough for routine clinical use.



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We incorporated the paramagnetic oxygen sensor into our new generation of compact anaesthesia monitors, starting with the Cardiocap™ all-in-one cardiac and airway gas monitor.

1986 Datex responded to requests from anaesthetists for integrated monitoring of all the airway gases, including anesthetic agents, by introducing the Capnomac™ Anaesthesia Multigas Monitor.

The Datex Cardiocap™ patient monitor combines all the essential airway and circulatory parameters.

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Accurate breath-by-breath measurement of anaesthetic dose now gives the anaesthetist the means to explore the potential of low-flow circle systems without compromising patient safety.

Using Capnomac™ to optimize the delivery of anaesthetic also allows the wastage of anaesthetic gases to be curtailed, with considerable savings in costs for the hospital.

The ability to both increase patient safety and reduce costs assured the popularity of Capnomac™ to such an extent that, within a year, it was the best-selling monitor of its kind.

1987 Standards for minimal intra-operative monitoring became a key issue in virtually all anaesthesia forums around the world in 1987.

The publication of the ASA standards and the revised Harvard recommendations for minimal monitoring underlined the importance of CO_2 monitoring for assuring patient safety during anaesthesia.

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1988 Today, capnometry has gained wide acceptance as one of the most important standards of minimal monitoring.

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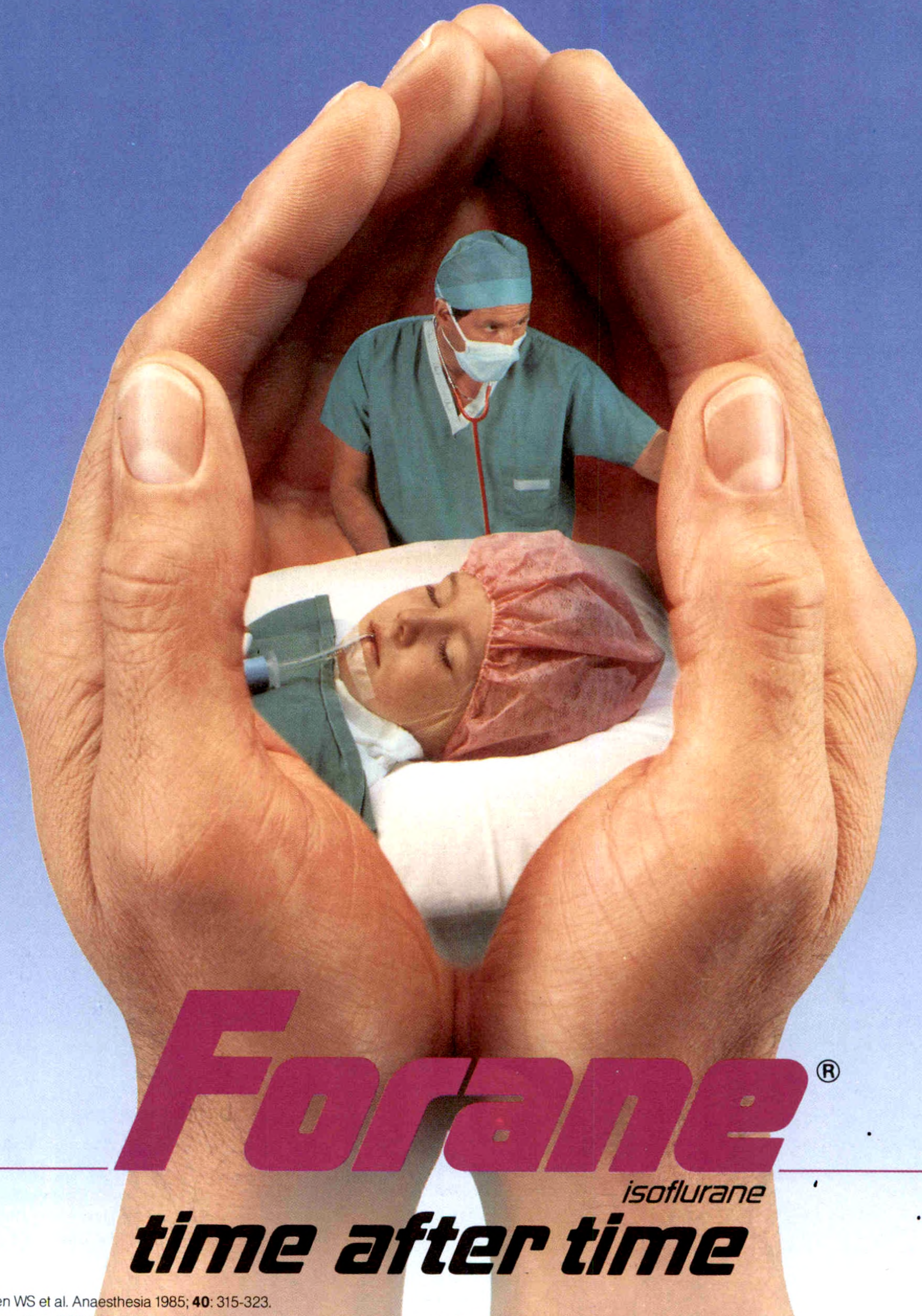

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Anaesthesia, 1988, Volume 43, pages 823–824

Editorial

Anaesthetists and the need to implement change

The public mind has been focused in recent months on the acute services of the NHS in a manner which has brought into open discussion matters which have been of concern to clinicians for some time. The apparent and real shortfall in the funding of the acute hospital sector within the increased monies for the NHS as a whole had become evident to many anaesthetists. There will remain a continuing problem as to whether the state can provide the finance to keep apace with technological advance and an ageing population whatever the end-results of recent changes in funding. The more esoteric and highly expensive supra-Regional services present financial problems for the NHS, but these are significantly of less importance than the widespread improvements in staffing and the rise of medical and technical advances for the average patient over the last 10 years. Anaesthetic departments and intensive care units in many district general hospitals have raised their standards to that of a few centres of excellence only a few years ago. This has not happened by chance, but by the combined efforts of enthusiastic young consultants and far-sighted seniors. It is an expensive process; expensive in terms of drive and commitment by anaesthetists and of cash-limited resources. Such is the expertise required and resources demanded by high standards that they cannot be spread thinly. Politicians and the public continue to press health authorities to provide complete staffed facilities at multiple sites throughout their district/area to cover all urgent and emergency problems. Rationalisation of services, and that normally means concentration of services, is the avenue down which authorities, supported by anaesthetists, ought to go. This may not be a popular view locally, but anaesthetists have a responsibility to inform and explain why staff and equipment required are such that they can only be made available if they are concentrated in sufficient quantities. We are equipped uniquely in terms of breadth of knowledge of the acute services and what can be achieved for the acutely ill patients if the appropriate facilities are available. There remain certain simple but fundamental principles to be observed, whether it be the siting of obstetric units, accident and emergency departments, intensive care units or an emergency surgical unit. Appropriately trained medical and nursing staff need to be available in adequate numbers over the 24 hours and for 7 days a week. Resuscitation and monitoring equipment must be readily available for use and fully serviced. The back-up services of investigative medicine in laboratory and imaging departments must be quickly accessible. These criteria are usually understood and accepted by those who give the problem serious thought, but this clarity of thought becomes clouded when superficial popularity is courted by politicians, both national and local. Many of these changes cannot be made instantly but, after 40 years, the NHS should be able to plan further ahead than crisis management and ensure that our acutely ill patients receive the standard of treatment they deserve and we can provide.

Most anaesthetists will have read the *Report of the confidential enquiry into perioperative deaths* (CEPOD) in full, and all will at least be aware of its recommendations. I hope I make this statement as a matter of fact rather than speculation, because we are about to embark on National CEPOD and it is important that lessons are learnt, and can be seen to be learnt, from the first Enquiry as we proceed to future studies. National CEPOD is a major cooperative venture between anaesthetists and surgeons from different disciplines. It now involves our Association and the Faculty of Anaesthetists of the College of Surgeons, the Association of Surgeons, the British Orthopaedic Association, the British Association of Urological Surgeons, the Royal College of Obstetricians and Gynaecologists, the Royal College of Pathologists, and the Royal College of Surgeons, and the Faculty of Community Medicine of the Royal College of Physicians of the United Kingdom. Professor Donald Campbell of Glasgow chairs the like-minded group who oversee the project, while the onerous detailed work is undertaken by John Lunn and Brendan Devlin. The Council of the Royal College of Surgeons has endorsed the findings of the enquiry which thus became the policy of the College in terms, particularly, of recognition of posts for General and Higher professional training. The immediate implication of this is that Regional Educational Advisors in Surgery are now directly, through College tutors, to be involved in ensuring that every member of staff cooperates fully in the new National CEPOD.

The first study, undertaken by our Association and the Association of Surgeons, examined all perioperative deaths in three Regions. The new one, funded by the Department of Health and Social Security, will now go nationwide. It is expected to examine selectively a sample from all perioperative deaths in certain operative headings or age groups. This will require the willing cooperation of anaesthetists on a much wider scale than formerly, when a very high percentage of anaesthetists fully participated in the three Regions, Northern, South Western, and North East Thames. This ensured its success which, in this context, can be measured by the collection accurately and expeditiously of relevant data and its expert analysis.

Two important recommendations must not be forgotten. Patients who are considered major anaesthetic risks ought to be treated by experienced senior doctors; this includes emergencies and urgencies, perhaps particularly includes emergencies and urgencies. These do not normally have a special interest group, either surgical or anaesthetic, who look after their interests. 'Emergencies', by their very nature, cannot be anticipated, but many 'urgencies' would benefit by a few hours' planning and treatment undertaken under more controlled circumstances by senior doctors in the light of day. To suggest that this can be done in every case is more easily proposed in an Editorial in *Anaesthesia* than in the harsh reality of a cash-hungry service. However, in some hospitals there is an empty theatre available during the day. Rotas and work programmes might be arranged to take note of, and make use of, facilities available. Anaesthetists should be to the fore in the initiation of such

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rational planning. They should be seen to be taking a lead in making anaesthetists of appropriate seniority available to undertake such work. They may have to go further and give consideration to restricting certain 'urgencies' outside designated hours, unless alternative arrangements can be made by interdisciplinary planning.

The major portion of anaesthetic work is carried out in conjunction with colleagues of different surgical disciplines. The CEPOD Report recommended that examination of current anaesthetic/surgical practice should be carried out by regular joint meetings of the anaesthetic/surgical divisions. This would be additional to the internal management of the anaesthetic division. Several surgical divisions have recently set up their divisional meetings at monthly intervals on successive afternoons of the week, to be followed by a morbidity meeting. Some coordination with anaesthetic meetings on these days would provide a forum for joint meetings at agreed intervals.

Other recommendations are being made by this Association about the use of monitoring equipment in the operating theatre. Each division of anaesthesia needs to give serious considerations as to how they can acquire the appropriate amount of monitoring equipment, but the individual anaesthetist must never forget that the best and primary monitor is the trained anaesthetist at the head of the table, observing both patient and the secondary data and taking the appropriate action.

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M.M. Burrows
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Editorial

Anaesthesia

Copy for *Anaesthesia News* should be sent to the Editor as and when it becomes available. It is hoped that publication will occur within 2 months of receipt.

Manuscripts must be submitted in accordance with the internationally recognised *Uniform requirements for manuscripts submitted to biochemical journals* (*British Medical Journal* 1979; **1:** 432 5). Details will be found in the Notice to Contributors to *Anaesthesia* at the end of this issue.

Anaesthesia, 1988, Volume 43, pages 825–828

Factors that influence cutaneous reactions following administration of thiopentone and atracurium

A. G. A. LYNAS, R. S. J. CLARKE, J. P. H. FEE AND J. E. REID

Summary

Atracurium was administered by a variety of techniques to determine whether these influence the onset or duration of muscular relaxation, and the frequency of cutaneous reactions, after a standard induction dose of thiopentone. One-hundred-and-fifty patients were allocated randomly to receive the drug by one of five methods: into a fast-flowing crystalloid infusion in the antecubital fossa; into a winged needle in the antecubital fossa with flushing after the thiopentone; into a winged needle in the antecubital fossa without flushing; into a winged needle in the dorsum of the hand without flushing. The above groups received atracurium freshly removed from the refrigerator whereas the fifth group were given atracurium which had been maintained at room temperature for at least 2 weeks. The frequency of cutaneous reactions was between 60 and 70% overall and there were no significant differences either in this or in the onset or duration of action between the groups. A further 25 patients with a history of drug allergy were also investigated by the first method and showed no significant differences in response, but 25 patients aged over 70 years had a significantly lower frequency of cutaneous reactions with a higher frequency of hypotension than the other groups.

Key words

Neuromuscular relaxants; atracurium.
Complications; cutaneous reactions.

Atracurium, a recently-introduced, non-depolarising neuromuscular blocking agent, had been shown to have several advantages over the long established pancuronium and tubocurarine. Among these are greater cardiovascular stability,[1,2] faster onset time and predictable duration of action,[3,4] lack of cumulative effects[5] and unique mode of degradation (Hofmann elimination) which is not dependent on hepatic metabolism or renal excretion.[6,7]

However, since the introduction of atracurium in the United Kingdom there have been several reports of its histamine releasing potential,[8] which produces both histaminoid cutaneous reactions[9] and, more rarely, hypotension and bronchospasm.[10] The observed incidence of these reactions has varied widely between different centres, for example, 54, 50, 47, 30, 25 and 10% have all been reported as the incidence of cutaneous reactions after administration of thiopentone and atracurium.[8,9,11–14] So far no proven explanation for this diversity of frequency has been put forward, though the manufacturers of atracurium (Calmic Medical Division, The Wellcome Foundation) believe that precipitation between the alkaline induction agent thiopentone (pH = 10.5) and the acid atracurium (pH = 3.5) in the intravenous needle tubing may be responsible for cutaneous reactions.[14] The recommended method of administration involves either the use of a fast-flowing intravenous infusion, or flushing of a winged intravenous needle with isotonic saline between the administration of thiopentone and atracurium, the latter injected over 15–20 seconds. It is also recommended that atracurium is stored at 4°C until use to avoid its degradation at ambient theatre temperature and the possible formation of by-products which could cause reactions. This degradation might also be expected to delay onset of paralysis or shorten its duration.

Method

A randomised clinical trial was designed to investigate some of the factors which might influence the occurrence of cutaneous reactions. Approval was obtained from the local medical ethics research committee and informed consent was obtained in each case. One-hundred-and-fifty patients in ASA groups 1 or 2 who underwent elective surgery and required ventilation, were allocated at random to one of the five equal groups below. The influence of the method of administration on the incidence of cutaneous reactions was assessed with four techniques, the first two of which are the manufacturer's recommended methods of admini-

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stration. Group 1, fast-flowing intravenous crystalloid infusion via 16-G cannula in antecubital fossa; Group 2, 23-G winged intravenous needle in antecubital fossa with flushing between the induction agent and the atracurium; Group 3, 23-G winged intravenous needle, antecubital fossa, no flushing; Group 4, 23-G winged intravenous needle, dorsum of hand, no flushing.

Atracurium for the above four groups was kept at 4°C until immediately before use. A fifth group received atracurium which had been left at room temperature for at least 2 weeks. This was to allow for the possibility of the occurence of Hofmann degradation in the ampoule which could liberate products that could cause cutaneous reactions. Two additional groups were also investigated; patients with a known history of drug allergy (n = 25) and elderly patients (> 70 years of age) (n = 25). The latter three groups received the atracurium by the Group 1 method of administration.

Anaesthesia was induced with thiopentone 5 mg/kg, followed 60 seconds later by atracurium 0.5 mg/kg given over 20 seconds. The trachea was intubated 60–90 seconds later and patients were ventilated with nitrous oxide and oxygen to normocapnia; anaesthesia was maintained with increments of midazolam and fentanyl.

Cutaneous reactions were noted, if present, by an observer unaware of what technique had been used and classified as mild, moderate or severe, depending on the intensity and extent of the skin erythema. Arterial blood pressure was measured at one-minute intervals with a Dinamap oscillotonometer (Critikon Ltd). The presence or absence of hypotension (> 40 mmHg from control) and bronchospasm (audible on routine auscultation) were also noted. The onset of neuromuscular blockade was recorded by loss of response to train-of-four stimulation from a Myotest peripheral nerve stimulator. Duration of block was determined by the time taken for all four responses to return.

The groups studied were broadly comparable with respect to age and weight (Table 1), except of course for the elderly group where the mean age was 75.6 years. The results were analysed using Chi-squared and Student's t-tests where appropriate.

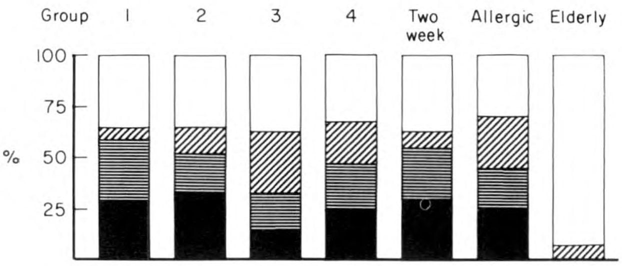

Fig. 1. Incidence of cutaneous reactions in the seven groups of patients. ■, severe; ▤, moderate; ▨, mild.

Results

Cutaneous reactions occurred frequently in all groups with the exception of the elderly who had significantly fewer reactions ($p < 0.01$) (Table 2). Figure 1 shows the incidence of cutaneous reactions in each group by severity. Again there were no marked differences between the groups with the exception of the elderly group where the low incidence shown represents just two patients who had a mild reaction. The patients who gave a history of allergy included 17 allergic to penicillin, five to other antibiotics, one to naproxen, one to Althesin and one to shellfish. The mean duration of reactions was 9.7 (SD) 0.9 minutes.

The patients who received the atracurium through a winged intravenous needle located in the dorsum of the hand often (60%) exhibited a cutaneous flush which extended proximally along the forearm. This flush delineated the venous drainage of the upper limb, with, in four cases, small wheals which occurred along the lines of venous drainage. Hypotension, as might be expected, was more common in the elderly group but none of the patients who displayed hypotension required resuscitation. There

Table 1. Anthropomorphic data in the seven groups; the first four represent the different methods of atracurium administration. Values expressed as mean (SEM).

Group	1	2	3	4	5	Allergic	Elderly
Storage temperature	4°C	4°C	4°C	4°C	Ambient	4°C	4°C
Age, years	47.2 (2.4)	38.7 (2.3)	44.3 (2.6)	39.8 (2.7)	38.5 (3.1)	45.1 (3.6)	75.6 (1.0)
Weight, kg	62.9 (3.4)	66.9 (2.2)	69.4 (2.3)	65.9 (2.3)	64.2 (2.3)	63.8 (2.3)	60.7 (2.7)

Table 2. Findings in the seven groups.

Group	1	2	3	4	5	Allergic	Elderly
Cutaneous reactions	63	67	60	70	63	72	8
Hypotension (%) (40 mmHg)	13	3	17	7	20	12	64
Onset of block, seconds, mean (SEM)	259.7 (16.4)	250.9 (11.7)	277.6 (22.9)	239.7 (14.3)	267.2 (14.0)	264.3 (20.6)	356.3 (30.1)
Duration of block, minutes, mean (SEM)	24.7 (1.3)	23.9 (0.7)	23.9 (1.0)	23.6 (0.9)	21.9 (0.9)	22.3 (0.9)	19.6 (1.5)

was no relationship between the occurrence of hypotension in individuals and presence or severity of cutaneous reactions.

Surprisingly, the atracurium stored at room temperature for 2 weeks did not appear to have lost any of its potency as indicated by the onset and duration of the block. The onset and duration in the elderly group tended to indicate a reduction in effect, although the figures were not significantly different from those in Group 1. Three patients out of the 200 in the study developed bronchospasm after atracurium. None caused any difficulty in ventilation and in all the signs resolved spontaneously.

Discussion

The high incidence of cutaneous reactions observed, compared with previously reported studies, may be explained by two factors. Firstly, the observed reactions were almost entirely truncal in distribution and would not have been observed without the removal of the patient's theatre gown immediately after induction. Secondly, the cutaneous reactions were short-lived and their disappearance had occurred usually by the time the patient had been moved into the operating theatre.

It was not possible in this study to investigate the mechanism of erythema after atracurium but it was hoped that it would clarify some factors. Other studies have shown that atracurium raises plasma histamine level[15,16] but there is no evidence of a dose correlation between this and cutaneous erythema. In fact Watkins[17] has shown that patients can have a marked cutaneous response to a substance without any rise in plasma histamine. The cutaneous response in the majority of the present series was not accompanied by hypotension or bronchospasm and therefore probably represented a localised release of histamine or other vaso-active substances.

The stimulus for the cutaneous erythema could be atracurium itself or one of its degradation products. These have been identified by Stenlake and colleagues[18] as laudanosine, a quaternary mono-acrylate which results from Hofmann elimination and the quaternary alcohol and acid which come from ester hydrolysis. Both reactions occur more rapidly in alkaline conditions so that potency and duration of full block are reduced, and recovery is hastened by alkalosis.[19] The fact that no such effects on the block were seen in the present study when atracurium and thiopentone were administered through the same needle suggests that any chemical interaction was minimal. It is unlikely that these reactions can be atrributed to this type of mixing, since there was no difference in the frequency of cutaneous erythema, though some precipitation of thiopentone salt in the tubing was sometimes seen to occur.

Thiopentone itself may occasionally produce a transient urticarial rash[20] but the incidence is not thought to be greater than 4%. Interaction with an alkaline induction agent cannot be associated with the finding[21] that nine out of 10 patients who received midazolam (pH 3.5) for induction developed skin flushes after administration of atracurium. Hofmann elimination and ester hydrolysis are also hastened as the temperature is raised. However, the fact that the time of onset of block was neither significantly longer nor recovery more rapid in the group that received atracurium kept at room temperature indicates that no important breakdown occurs in these conditions over 2 weeks. Again this group showed no difference in frequency of cutaneous erythema from Group 1.

A history of drug allergy is known to occur in approximately 13.5% of surgical patients[22] and such patients frequently but not always have IgE titres significantly above the normal range.[23] Failure to find any increase in frequency of reactions in these patients suggests that they are not immune-mediated and that it is likely that direct liberation of histamine by the atracurium itself is involved. The low incidence of reactions in the older patients is most readily explained by their slower circulation time. Certainly it has been shown[16] that slow administration of atracurium induces less histamine liberation and its effects than when the drug is given rapidly. However, the elderly group had hypotension more frequently than those younger and this may mean that there was more liberation of histamine in the plasma but that less affected the cutaneous vessels, or it may indicate an alteration in receptor sensitivity. An alternative explanation is that the hypotension was caused by the thiopentone rather than the atracurium.

In conclusion, none of the methods of administration studied had any influence on the neuromuscular blocking action or frequency of cutaneous side effects when thiopentone was given followed by atracurium and there is no reason to alter one's anaesthetic technique when using this drug. In addition there appears to be no reason to avoid its use in patients with a history of drug allergy.

References

1. Goudsouzian NG, Liu LMP, Cote CJ, Gionfriddo M, Rudd GD. Safety and efficacy of atracurium in adolescents and children anesthetized with halothane. *Anesthesiology* 1983; 59: 459–62.
2. Eagar BM, Flynn PJ, Hughes R. Infusion of atracurium for long surgical procedures. *British Journal of Anaesthesia* 1984; **56:** 447–52.
3. Ward S, Wright D. Combined pharmacokinetics and pharmacodynamic study of a single bolus dose of atracurium. *British Journal of Anaesthesia* 1983; **55:** 35S–8S.
4. Schiller DJ, Feldman SA. Comparison of intubating conditions with atracurium, vecuronium and pancuronium. *Anaesthesia* 1984; **39:** 1188–91.
5. Payne JP, Hughes R. Evaluation of atracurium in anaesthetized man. *British Journal of Anaesthesia* 1981; **53:** 45–54.
6. Hunter JM, Jones RS, Utting JE. Use of atracurium in patients with no renal function. *British Journal of Anaesthesia* 1982; **54:** 1251–8.
7. Ward S, Neill EAM. Pharmacokinetics of atracurium in acute hepatic failure (with acute renal failure). *British Journal of Anaesthesia* 1983; **55:** 1169–72.
8. Barnes PK, Watkins J, de Renzy-Martin N, Thomas VJE. Plasma histamine concentrations after administration of atracurium. *British Journal of Anaesthesia* 1984; **56:** 795P.
9. Mirakhur RK, Lyons SM, Carson IW, Clarke RSJ, Ferres CJ, Dundee JW. Cutaneous reaction after atracurium. *Anaesthesia* 1983; **38:** 818–9.
10. Siler JN, Mager JG, Wyche MQ. Atracurium: hypotension, tachycardia and bronchospasm. *Anesthesiology* 1985; **62:** 645–6.
11. Coleman P, Hunter JM, Hunt DP. Local reaction following atracurium. *Anaesthesia* 1983; **38:** 1009–10.
12. Rowlands DE. Atracurium—cutaneous reactions. *Anaesthesia* 1983; **38:** 1232–3.
13. Cozanitis DA, Hofmockel R, Benad G. Skin reactions to the newer non-depolarising neuromuscular blocking drugs. *Anaesthesia* 1984; **39:** 500–1.
14. Fox MA. Atracurium in normal doses may release histamine. *Anesthesiology* 1984; **60:** 386.

15. Basta SJ, Savarese JJ, Ali MM, Moss J, Gionfriddo M. Histamine-releasing potencies of atracurium, dimethyl tubocurarine and tubocruarine. *British Journal of Anaesthesia* 1983; **55:** 105S–6S.
16. Scott RPF, Savarese JJ, Basta SJ, Sunder N, Ali HH, Gargarian M, Gionfriddo M, Batson AG. Atracurium: clinical strategies for preventing histamine release and attenuating the haemodynamic response. *British Journal of Anaesthesia* 1985; **57:** 550–3.
17. Watkins J. Mechanisms and factors predisposing towards adverse response to intravenous anaesthetic substances. In: Thornton J, ed. *Adverse reactions to anaesthetic drugs.* Holland: Elsevier, 1981: 136-67.
18. Stenlake JB, Waigh RD, Urwin J, Dewar GH, Coker GG. Atracurium: conception and inception. *British Journal of Anaesthesia* 1983; **55:** 3S–10S.
19. Hughes R, Chapple DJ. The pharmacology of atracurium: a new competitive neuromuscular blocking agent. *British Journal of Anaesthesia* 1981; **53:** 31–44.
20. Dundee JW, Wyant GM. *Intravenous anaesthesia*, Edinburgh: Churchill-Livingstone, 1974: 102.
21. Ferres CJ, Carson IW, Lyons SM, Orr IA, Patterson CC, Clarke RSJ. Haemodynamic effects of vecuronium, pancuronium and atracurium in patients with coronary artery disease. *British Journal of Anaesthesia* 1987; **59:** 305–11.
22. Dundee JW, Fee JPH, McDonald JR, Clarke RSJ. Frequency of atopy and allergy in an anaesthetic patient population. *British Journal of Anaesthesia* 1978; **50:** 793–8.
23. Watkins J, Clarke RSJ, Fee JPH. The relationship between reported atopy or allergy and immunoglobulins: a preliminary study. *Anaesthesia* 1981; **36:** 582–5.

Anaesthesia, 1988, Volume 43, pages 829–832

Postoperative recovery rooms

Staffing and facilities in three regions in the United Kingdom

C. S. GOODCHILD

Summary

Postoperative recovery rooms have been used in the United Kingdom for just over 30 years. Anaesthetic and surgical practices have improved during this time but the clinical problems encountered are unchanged essentially. Several surveys have reviewed complications that occur; the most common causes of postoperative morbidity and mortality are still cardiovascular and respiratory problems, the latter particularly of the upper airway. In contrast there are no data available on the standard of staff and equipment in recovery rooms. The results of a survey of this aspect of postoperative recovery rooms in hospitals in Wessex, North West Thames and Yorkshire Regional Health Authorities are reported. Particular effort was made to define the facilities available. The results indicate that 70% of hospitals do not provide staffing levels and facilities which meet recommendations of the Association of Anaesthetists of Great Britain and Ireland. The implications of these findings with regard to anaesthetic morbidity and mortality are discussed.

Key words

Recovery.
Monitoring.

Jolly and Lee stressed in an article in *Anaesthesia* in 1957[1] the desirability of postoperative observation wards. They described causes of death in the immediate postoperative period: airway obstruction, cardiovascular problems, inhalation of blood or vomit and inadequate respiratory exchange as a result of either partial curarisation or respiratory depression from opiates and anaesthetic agents. They quoted a study that reported 307 deaths associated with anaesthesia in which half were judged to be preventable; 63% of these were because of respiratory obstruction and inadequate nursing after operation. They argued that greater safety would be achieved by centralisation of care and specialised equipment in a postoperative recovery room. Fewer nursing staff would be necessary but they could be specially trained in the care of such patients. They argued further that the increased safety margins thus obtained would decrease any medicolegal problems associated with postoperative morbidity and mortality.

Marked improvements have occurred since the 1950s in anaesthetic and operative techniques and also in the standards of equipment and staffing of anaesthetic rooms and the operating theatre. Lunn and Mushin's survey of mortality showed that in spite of this one third of patients who died, within 6 days of their operations, were denied the benefits of proper recovery facilities.[2] The present survey set out to determine the current state of recovery room practice, with particular reference to staffing levels and equipment.

Methods

Sixty-nine hospitals in North West Thames, Yorkshire and Wessex Regional Health Authorities were sent a questionnaire. Two identical questionnaires, in five sections, were sent to each hospital: one to the Chairman of the Division of Anaesthetics and the second to the Operating Theatre Manager.

Number and location of recovery areas

Participants were asked to complete a table that detailed the number of separate locations at which patients were anaesthetised. All sites which were physically separate were included, for example, two locations were recorded for two suites of operating theatres. X ray departments, psychiatric departments, obstetrics, casualty and outlying hospitals which did not have a separate department of anaesthesia (psychiatric or geriatric hospitals, or nursing homes and dental surgeries) were recorded as separate sites. Details of the number of operating theatres involved at each site were also sought. Therefore this yielded information on the number of different areas at which patients were recovering from anaesthesia and about specialist units, separate from main-site facilities (maternity, and orthopaedic hospitals). Many hospitals however include such specialist areas in the main operating theatre site; these were not reported separately and did not appear as separate figures.

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Table 1. Number of recovery bays per operating theatre. Values expressed as mean (range).

	Specialist areas separate from the main operating theatre complex						
	Main	Casualty	X ray	Psychiatry	Maternity	Day care	Others
Teaching hospitals	0.82 (0.6–2.0)	0.50 (0–0.50)	0.31 (0–1.0)	2.0 (0–6.0)	0	4.5 (0–6.0)	1.63 (0–1.75)
Nonteaching hospitals	0.64 (0–4.0)	0.78 (0–3.0)	0.24 (0–2.0)	1.33 (0–10)	0.57 (0–2.0)	1.93 (0–11)	1.04 (0–3.0)

Staffing

Questions were asked about the provision and grade of anaesthetists with special responsibilities for the recovery room, about nursing staffing per bed space, and the ratio of qualified staff to student nurses. Participants were also asked whether the nurses were devoted solely to recovery room practice or had other duties in the main operating theatre complex at the same time. Nursing staff training was also considered; in particular, the question of special training programmes for recovery room practice and inservice education.

Facilities

Participants were asked how many patient bed spaces were available. Thereafter, enquiries were made about the availability of the following at each bed space: piped oxygen, nitrous oxide, or suction; portable suction units; tipping beds or trolleys; ECG monitors; defibrillators and equipment for resuscitation; intermittent positive pressure ventilation; automated blood pressure recorders; capnographs; and apparatus for invasive arterial pressure monitoring.

Techniques

The function of this section was to determine at how many hospitals, and in how many recovery rooms, the following techniques were, or could be, instituted: mechanical ventilation of the lungs; electrocardiographic monitoring in some or all patients; invasive cardiovascular monitoring by arterial line or central venous pressure (CVP); analgesia by continuous infusion of opiates or epidural local anaesthetics, and overnight stay.

Hours of work

These answers indicated whether the recovery rooms were staffed throughout the day and if staffing were substantially reduced at night. They were also designed to reveal details of minimum length of stay per patient, if such a policy had been established, and any other comments.

Results

Questionnaires were returned from 56 hospitals (81% response rate). The number of recovery bays per operating theatre (Table 1) in each location were derived from the data given on staffing and numbers of recovery rooms and their locations. It was the responsibility of the individual anaesthetist in many hospitals to supervise the postanaesthetic care of the patient in the recovery ward. Table 2 shows the availability of anaesthetists with special responsibility for recovery. There was an average of 0.84 nurses available per recovery bay and the ratio of qualified staff to students was 2:3. Eighty percent of these nurses were totally devoted to recovery room practice; 20% also had other duties in the operating theatre complex; 50% were trained specially and 93% also received inservice training.

Table 2. Anaesthetists responsible for recovery.

	None	Some	Grade
Teaching hospital	7/8	1/8	Consultant
Nonteaching hospital	40/48	8/48	4 consultant 3 registrar 1 other

Facilities

The total number of recovery bays reported was 641; 34% of which provided 24-hour cover. Eighty-eight percent were supplied with piped oxygen, all the others by oxygen cylinders on the trolleys. Nine percent of recovery bays were supplied with nitrous oxide; 80.7% had piped suction and 99% tipping trolleys. The shortfall in suction apparatus was met by portable units except for one recovery bay which had neither; ECG machines were supplied for 35%. Resuscitation equipment (such as defibrillators,) for 11% of recovery wards was situated at another site. A ventilator was available in at least one recovery area in 94% of hospitals. Fifty percent of hospitals said they had noninvasive blood pressure machines and capnographs for use in the recovery ward; most had to be transferred from the operating theatre.

Techniques

The ECG was monitored in all patients in about a third of hospitals, while the rest (67.8%) monitored it in selected patients. Central venous pressure or an arterial line was used in 48% of hospitals; mechanical ventilation of the lungs in 76%; continuous opiate intravenous infusion in 58.9%; continuous epidural infusion with local anaesthetic in 71.4%; and overnight facilities in 19.6% of hospitals.

Hours of work

In hospitals where no recovery staff were available during emergency hours (66%), the patients were cared for during recovery either by the anaesthetist or, more commonly, by a nurse from the theatre.

Discussion

This survey provides new information which allows comparison of recovery room staffing and facilities available with recommendations made previously by the Faculty of Anaesthetists of the Royal College of Surgeons of England[3] and the Association of Anaesthetists of Great Britain and Ireland.[4] The results from the present survey show that many hospitals do not fulfil these minumum requirements.

Staffing

The ratio of nurse to patient was frequently less than the one-to-one recommended (0.84 mean number of nurses per recovery bay). Eighty percent of these nurses were allocated solely to recovery room duties and the ratio of qualified staff to student nurses was 2:3 that is, 30% of the nurses who worked in recovery rooms were unqualified. This ratio is much larger in some hospitals since a minority stated clearly that all student nurses were supernumerary. This must mean that many patients are supervised by unqualified nurses during recovery from surgery and anaesthesia.

Fewer than 20% of hospitals permitted patients anaesthetised during the day to remain in the recovery room overnight. This figure is substantially short of the 34% who claimed to staff recovery throughout the 24-hour period. The difference between these two figures might be explained by hospital policies which prevent the routine overnight sojourn of patients anaesthetised during the day.

The majority of hospitals that returned completed questionnaires offered an acute surgical service but it must be concluded that 66% of hospitals that offer such a service do not have 24-hour recovery facilities and therefore do not fulfil this particular recommendation made by the Association of Anaesthetists. It also means that patients in those hospitals anaesthetised during the night are handed over to ward or surgical nurses doubling up in the recovery ward. It is unknown what percentage of these are trained specifically for recovery ward practice.

Equipment

The Association of Anaesthetists recommended that an average of 1.5 recovery bays should be available for each operating theatre and that more should be provided if high turnover specialties are involved, for instance ENT, GU or daycase surgery. This is about twice that generally available (Table 1). Most recovery bays had essential equipment such as tipping trolleys, suction apparatus and oxygen. The poor availability of ECG machines is indicated in the mere 30% of patients in whom it is practised routinely. Resuscitation equipment for 11% of recovery areas is situated at another site, many of which were isolated units, which presumably reflects in monetary terms the number of times per year that that equipment is likely to be used. The use of a ventilator in at least one recovery ward in a hosptial was quite common (93%) but automatic ventilation of the lungs was practised less frequently (76%). The difference between these two figures may be explained by the availability of suitably trained staff, particularly during the night.

Fitness for discharge and analgesia

Nitrous oxide was available in only 9.4% of recovery wards, which presumably means that it is seldom used for postoperative analgeisa, while analgesia by continuous intravenous opiate or epidural local anaesthetic infusions was common and contrasts with the low incidence of facilities for overnight stay. These figures are interesting when one considers the Association of Anaesthetists's recommendations for discharge to the general ward; patients should be conscious with *normal reflexes*, able to maintain their own airway, and have stable cardiovascular systems.

It is not known what happens to patients who have had epidural analgesia and intravenous opiate infusions when they leave the recovery ward: sympathetic and motor blockade continues beyond the traditional recovery period after anaesthesia in those who have had epidural local anaesthetics, and postoperative oxygen desaturation for many hours is well recognised in association with opiate therapy.[5] These patients would therefore be suitable for a high dependency unit. A specific question about such units was not asked, but only two hospitals claimed to have access to one for the postoperative patient. It must be concluded that in many the more effective analgesic techniques are either stopped on discharge from the recovery ward or the patient is cared for and monitored on the general surgical ward. The destination and fate of these cases should be investigated in future surveys.

The incidence of postoperative complications

Postoperative complications occur frequently in the recovery ward. Many new anaesthetic techniques have been introduced, since the paper by Jolly and Lee,[1] together with improved standards in the anaesthetic room and the operating theatre. It might be assumed on this basis that the incidence of postoperative complications would diminish; however 25 years later the lack of proper postoperative care was still regarded as a contributory factor in 30% of postoperative deaths.[2] Many surveys have concluded that the incidence and severity of postoperative morbidity have changed little since 1957.[6–10]

Conclusions

Respiratory and cardiovascular complications after anaesthesia and surgery were the main reason for the introduction of postoperative recovery rooms in this country 30 years ago. The incidence and severity of these complications are still high in the immediate postoperative period and it is clear from this survey that many recovery wards in this country are staffed well below the level necessary to care for patients adequately. There is an urgent need for expansion of recovery room nursing staff in order to meet standards recommended nationally.

Acknowledgments

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References

1. Jolly C, Lee JA. Post-operative observation ward. *Anaesthesia* 1957; **12:** 49–56.
2. Lunn JN, Mushin WW. *Mortality associated with anaesthesia.* London: Nuffield Provincial Hospitals Trust, 1982.
3. Faculty of Anaesthetists of the Royal College of Surgeons of England. *General Professional Training Guide,* 1987.

4. Association of Anaesthetists of Great Britain and Ireland. *Post-anaesthetic recovery facilities,* 1985.
5. Catley DM, Thornton C, Jordan C, Lehane JR, Royston D, Jones JG. Pronounced, episodic oxygen desaturation in the postoperative period: its association with ventilatory pattern and analgesic regimen. *Anesthesiology* 1985; **63:** 20–8.
6. Harrison GG. Death attributable to anaesthesia. A 10 year survey (1967–1976). *British Journal of Anaesthesia* 1978; **50:** 1041–6.
7. Hovi-Viander M. Death associated with anaesthesia in Finland. *British Journal of Anaesthesia* 1980; **52:** 483–9.
8. Farman JV. The work of the recovery room. *British Journal of Hospital Medicine* 1978; **19:** 606–16.
9. Eltringham RJ. Complications in the recovery room. *Journal of the Royal Society of Medicine* 1979; **72:** 278–80.
10. Buck N, Devlin HB. Lunn JN. *The report of a confidential enquiry into perioperative deaths.* The Nuffield Provincial Hospitals Trust and The King's Fund, London, 1988.

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Identification of autonomic dysfunction with a pulse oximeter

I. J. BROOME AND R. A. MASON

Summary

Chart recordings of the pulse oximeter waveform were taken during the performance of a standard Valsalva manoeuvre, in one subject with and another without autonomic dysfunction. They demonstrate that certain types of pulse oximeter may be used for the rapid pre-operative identification of patients who have an autonomic neuropathy in which the cardiovascular responses to stress are impaired.

Key words

Equipment; pulse oximeter.
Complications; autonomic neuropathy.

Autonomic dysfunction is a complication of a number of disease processes. These include diabetes, Guillain-Barré syndrome,[1] familial dysautonomia,[2] Shy-Drager syndrome,[3] Parkinson's disease,[4] postcerebrovascular accident states and AIDS.[5] It has also been shown to be more common in elderly patients without organic disease processes[6] and may be present in patients who take certain cardiovascular drugs. Failure of the autonomic system will produce widespread disturbances in organ function, but it is the cardiovascular effects which are of particular concern to the anaesthetist. There is reversal of the usual diurnal and nocturnal variations in arterial blood pressure and also a disturbance of fluid and electrolyte homeostasis. This results in a failure to concentrate urine at night and so produces nocturnal diuresis and sodium loss.[4] However, the most serious consequence of autonomic failure is the impairment of the ability to produce a pressor response to stress. The autonomic system is responsible for the short-term regulation of arterial blood pressure by controlling adjustments to pulse rate, peripheral resistance and capacitance. The ability of a subject to compensate for hypotension, whether it be because of postural change, hypovolaemia, the onset of artificial ventilation or induction of anaesthesia, is governed largely by the integrity of the autonomic nervous system.

A number of peri-operative complications, which might be attributable to autonomic failure, have been described in association with both general and local anaesthetic techniques. These include cardiac arrest, dysrhythmias and severe hypotension.[7,8] It is important because of these for the anaesthetist to be able to identify pre-operatively those patients who are at risk. Several tests to assess autonomic dysfunction have been described. These are mostly based on arterial blood pressure and/or heart rate changes during the Valsalva manoeuvre, or after postural changes.[9,10] However, as Brown[11] has already observed, these tests are not easy to perform with sufficient accuracy in the absence of some means of continuously recording blood pressure or heart rate. Ideally, a simple method is required which will demonstrate instant changes in both arterial blood pressure and pulse rate. Direct arterial pressure monitoring will provide a continuous record of blood pressure and pulse, but is invasive. A number of complications have been reported from its use and in general it would not be practicable as a pre-operative test.

Changes in fingertip blood flow, as measured by a Periflux Laser Doppler Flowmeter,[6,12] have been shown to correlate well with changes in arterial blood pressure and heart rate seen during tests of autonomic function. The pulse oximeter also records fingertip blood flow, and so we decided to assess its potential role as a noninvasive monitor under these circumstances.

Method

A Criticare 502 pulse oximeter (Simonsen and Weel) was connected by means of a simple lead, so that the pulse waveform output was fed into an Engström Eliza chart recorder. The finger probe from the apparatus was clipped onto the middle finger of the subject, who lay supine with

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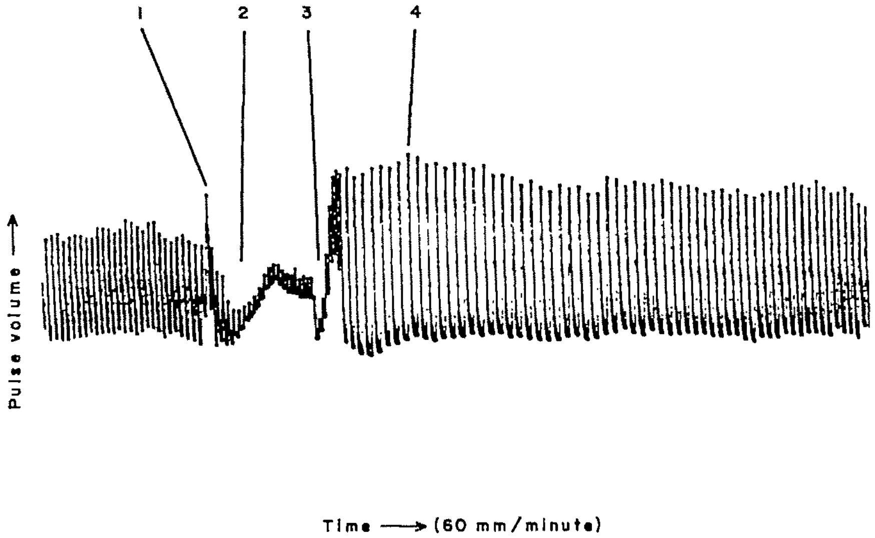

Fig. 1. A pulse oximeter recording of pulse waveform during a normal Valsalva manoeuvre showing Hamilton's four phases: 1. A rapid increase in arterial pressure (shown on the tracing as an increase in pulse volume) immediately after the onset of straining as the intrathoracic pressure is added to systemic arterial pressure; 2. A decrease in pressure accompanied by a tachycardia as a result of diminished venous return, with some restoration of pressure later in this phase; 3. A sudden brief further reduction in pressure immediately after the release of straining; 4. A terminal elevation of pressure above control levels associated with bradycardia. This is as a result of restoration of the venous return and cardiac output on release of the Valsalva manoeuvre, at a time when the peripheral vessels are still constricted. The arterial pressure increases above normal, the baroreceptors are stimulated and a bradycardia occurs until the pressure returns to its normal value.

his legs horizontal but his upper body raised to 45°. A Valsalva manoeuvre was then performed, by taking a maximum inspiration, blowing into a tube connected to a mercury manometer, and elevating the mercury level to 40 mmHg for 10 seconds. The presence of a slow blow-off valve required the subject to blow continuously to maintain pressure. The continuous forced expiration was terminated abruptly at the end of this period and the subject instructed to breathe as smoothly as possible.

A similar arrangement was then used on a patient with suspected autonomic dysfunction, who was in the Intensive Therapy Unit. He already had an arterial line *in situ*. A second Engström Eliza chart recorder was connected to the bedside Kone monitoring system and the patient conducted a Valsalva manoeuvre as already described. Simultaneous tracings from both the oximeter and the arterial line were obtained.

Results

The oximeter tracing from a subject with a normal autonomic system is shown in Fig. 1. All four phases of response, as originally described by Hamilton in 1936,[13] can be seen clearly. Figure 2 shows both the direct arterial and oximeter tracings in the patient with autonomic dysfunction. Here there is a 'blocked' response to the Valsalva manoeuvre.

Discussion

The presence of an autonomic neuropathy may result in serious cardiovascular complications during anaesthesia, so its pre-operative identification is important. In addition, autonomic neuropathy is one of the more serious complications of Guillain-Barré syndrome, and its progression in a patient who requires ventilation may herald a fatal dysrhythmia.[1] A simple noninvasive test would be of great value to the anaesthetist.

A variety of noninvasive methods to assess cardiovascular reflexes have been described, the majority of which are particularly relevant to physicians studying diabetic patients. The tests include the measurement of heart rate variations during the Valsalva manoeuvre, heart rate responses to standing up, R-R intervals during deep breathing and analysis of a 24-hour ECG for heart rate variations. Blood pressure responses to postural changes and sustained handgrip have also been measured.[9,14] However, it is recommended that several different tests be performed as autonomic dysfunction is not an 'all-or-none' phenomenon.[9] The reliance on one test alone, as suggested in several anaesthetic texts, may be misleading.[9] Most of the tests enumerated above require calculations to be made, and a knowledge of the ranges of the normal values.

The demonstration of an abnormal response to the Valsalva manoeuvre is also quoted widely as a method of assessment. However, continuous arterial blood pressure recording is necessary in order to show these changes. It can therefore be seen that, in the absence of direct arterial monitoring, no single test is entirely satisfactory for rapid pre-operative anaesthetic assessment.

Changes in fingertip blood flow, as measured by a Periflux Laser Doppler Flowmeter, have been used to assess autonomic function,[6,12] but as far as we are aware, it has not been used in the UK for this purpose. The pulse oximeter, however, is a piece of equipment which is becoming more commonly used by anaesthetists and is now available in many theatres. The addition of a chart recorder provides a useful method to assess and document autonomic func-

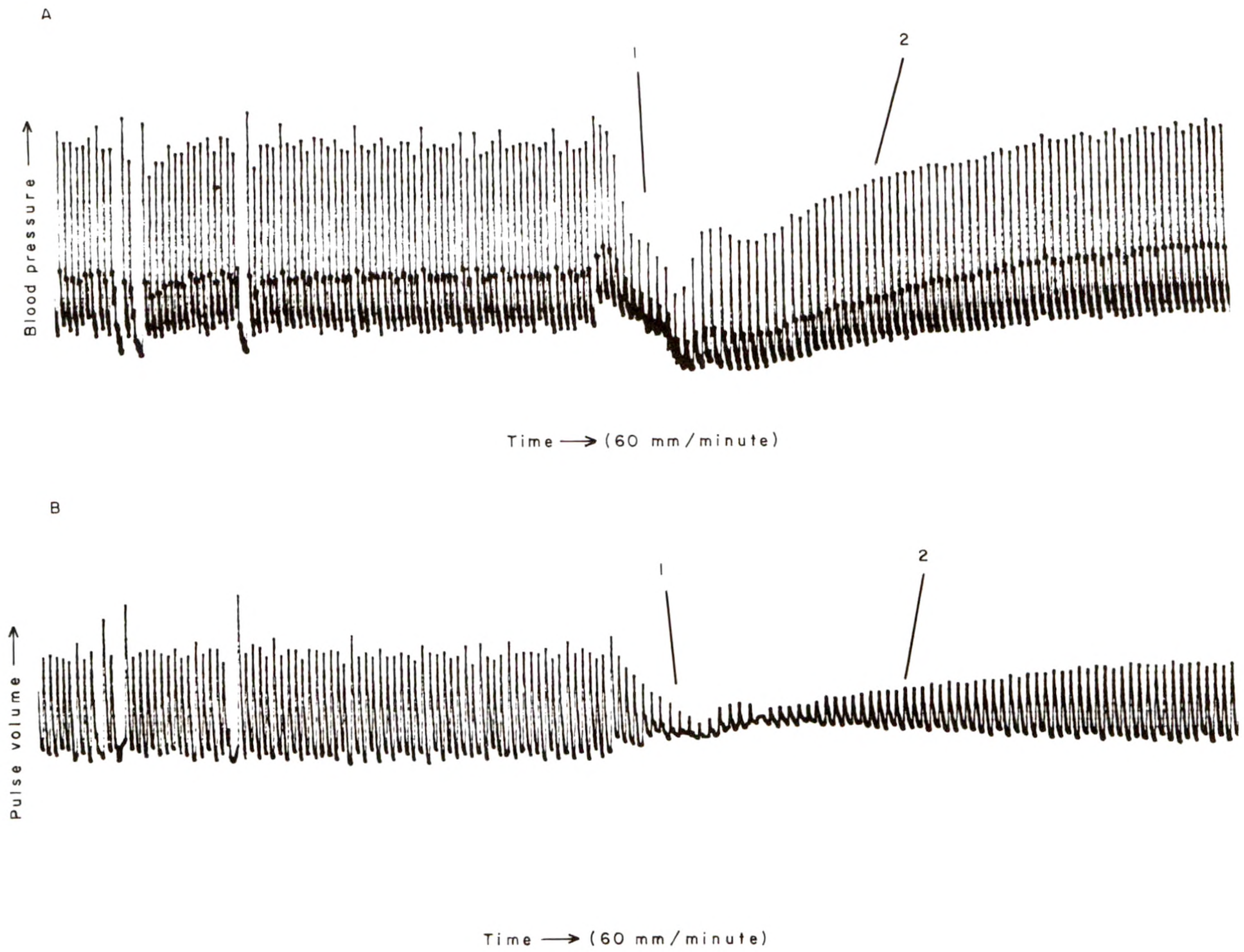

Fig. 2. Simultaneous pulse oximeter and direct arterial blood pressure recordings during a Valsalva manoeuvre in a patient with autonomic dysfunction. A, direct arterial blood pressure; B, pulse oximeter waveform; 1. The arteral blood pressure and pulse volume continue to decrease during the Valsalva manoeuvre as the patient is unable to respond by vasoconstriction; 2. The absence of rapid increase in cardiac output when the straining is released. The oximeter and blood pressure recordings only gradually return to normal.

tion, but even without this facility, it is easy to see the characteristic changes in waveform and pulse rate, without necessarily having to record them.

Not all pulse oximeters can be used for this purpose. The Criticare 502 oximeter was chosen for two reasons. First of all the pulse waveform can be obtained easily from one of the output connectors, without internal alteration. Secondly, once set, the gain on the waveform does not alter. This means that a diminished signal shows a smaller amplitude trace on the waveform recording. Initially the Ohmeda Biox 3700 was used, but this had to be abandoned, as the machine electronically adjusts the gain on the waveform signal every 6 seconds, in order to maximise the size of the waveform display.

The Criticare 502 oximeter gave remarkably reproducible results. However, it can probably be assumed that other pulse oximeters would be suitable if they fulfilled the criteria stated above. The presence of a waveform display is not essential, provided that there is a waveform output on the back of the machine.

These preliminary tests show that the pulse oximeter can be used to provide the anaesthetist with a rapid noninvasive method of assessing autonomic function. The characteristic changes in arterial pressure and pulse, which follow the execution of a Valsalva manoeuvre in patients with either normal or abnormal autonomic system function, are reflected in the pattern of pulse waveform produced by the oximeter.

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References

1. Oakley CM. The heart in the Guillain-Barré syndrome. *British Medical Journal* 1984; **288:** 94.
2. Stenqvist O, Sigurdsson J. The anaesthetic management of a patient with familial dysautonomia. *Anaesthesia* 1982; **37:** 929–32.
3. Hutchinson RC, Sugden JC. Anaesthesia for Shy-Drager syndrome. *Anaesthesia* 1984; **39:** 1229–31.
4. Watson RDS. Treating postural hypotension. *British Medical Journal* 1987; **294:** 390–1.
5. Craddock C, Pasvol G, Bull R, Protheroe A, Hopkin J. Cardiorespiratory arrest and autonomic neuropathy in AIDS. *Lancet* 1987; **2:** 16–8.
6. Oimomi M, Hatanaka H, Maeda Y, Hata F, Kitamura Y, Matsumoto S, Baba S. Autonomic nervous function determined by changes of periflux blood flow in the aged. *Archives of Gerontology and Geriatrics* 1986; **5:** 159–63.

7. Perel A, Reches A, Davidson JT. Anaesthesia in the Guillain-Barré syndrome. *Anaesthesia* 1977; **32:** 257–60.
8. Page M McB, Watkins PJ. Cardiorespiratory arrest and diabetic autonomic neuropathy. *Lancet* 1978; **1:** 14–6.
9. Ewing DJ, Clarke BF. Autonomic neuropathy: its diagnosis and prognosis. *Clinics in Endocrinology and Metabolism* 1986; **15:** 855–8.
10. Watkins PJ, Mackay JD. Cardiac denervation in diabetic neuropathy. *Annals of Internal Medicine* 1980; **92:** 304–7.
11. Brown MJ. The measurement of autonomic function in clinical practice. *Journal of the Royal College of Physicians* 1987; **21:** 206–9.
12. Oimomi M, Nishimoto S, Matsumoto S, Hatanaka H, Ishikawa K, Baba S. Evaluation of periflux blood flow measurement in diabetic patients with autonomic neuropathy. *Diabetes Research and Clinical Practice* 1985; **1:** 81–5.
13. Hamilton WF, Woodbury RA, Harper HT. Physiologic relationships between intrathoracic, intraspinal and arterial pressures. *Journal of the American Medical Association* 1936; **107:** 853–6.
14. McAloney R, Mitchell H, Deering AH, Shanks RG, Harron DWG. Computerized evaluation of Valsalva's manoeuvre before and during alpha-adrenoreceptor blockade with alfuzosin. *Journal of Pharmacological Methods* 1987; **18:** 163–77.

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Technical advantages of the paramedian approach for lumbar epidural puncture and catheter introduction

A study using epiduroscopy in autopsy subjects

R. G. BLOMBERG

Summary

The lumbar epidural space of 14 autopsy subjects was examined by epiduroscopy. The aim was to compare the midline and paramedian approaches of locating the space, the estimated risk of accidental dural puncture, the course taken by the epidural catheter after introduction and with special attention to the influence of the dorsomedian connective tissue band. The paramedian needle passed a greater distance within the epidural space before contact with the dura mater and demonstrated a low risk of accidental dural puncture. The catheter passed by the paramedian approach did not cause any tenting of the dura and took a straight cephalad direction in all 14 cases. The midline catheter caused tenting of the dura in all 14 cases and the direction of travel was variable. Differences were statistically significant. Influence of the dorsomedian connective tissue band was greatest on the behaviour of the midline needle and catheter.

Key words

Anaesthetic techniques; epiduroscopy.
Anatomy; epidural space.

Advantages of the paramedian approach for lumbar epidural anaesthesia have been claimed for many years. Bonica[1] in 1956, presented his results using this approach in a large number of patients. Other authors have reported favourable experiences verifying the advantages and have discussed the different mechanical factors concerned in the midline and paramedian approaches.[2–7]

From the technical point of view the paramedian approach has been stated to be associated with a lower risk of accidental dural puncture compared to the midline; allows a straighter course for the catheter in the epidural space; is associated with a lower frequency of intravascular cannulation and causes a lower incidence of paraesthesia. The difference in the angle of approach of the needles to the dura has been proposed as the important factor in this respect. Midline puncture still seems to be the dominant technique in the lumbar region, in the literature on epidural anaesthesia. Clinical comparisons of the two methods,[8,9] as well as radiological studies of the course of the epidural catheter,[10–15] have not presented consistent results.

In a recent examination of the lumbar epidural space of 48 autopsy subjects using epiduroscopy,[16] a dorsomedian connective tissue band was demonstrated between the dura mater and the ligamentum flavum which fixed the dura and caused a dorsomedian fold in it that could be seen in 46 of the 48 cases. The epidural space was expanded when necessary by small amounts of injected air and then usually readily remained open. Preliminary results of epiduroscopy *in vivo*[17] have, in contrast, demonstrated that the lumbar epidural space is more or less a potential space; the dura mater is in close contact with the dorsal aspect of the space, attached to it by the dorsomedian connective tissue band. The epidural space opened only temporarily in the living subject when small increments of air were injected. It is proposed that the different appearance of the epidural space in autopsy subjects is mainly because of the absence of a circulation and the very low pressure of the cerebrospinal fluid (CSF)[16]

A study was performed on autopsy subjects using endoscopy of the epidural space, epiduroscopy, to compare the lumbar midline and paramedian approaches in the same individual. The distance from the site of the ligamentum flavum puncture to the dura by the two techniques was compared to assess the risk of accidental dural puncture. The course of epidural catheters passed through both routes was also observed. An attempt was also made to determine what influence the dorsomedian connective tissue band might have on the course of the needle and catheter and to ascertain if any differences exist between the two techniques in this respect. The CSF pressure was restored to normal

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values during the course of the procedure in an attempt to eliminate one of the major differences between autopsy subjects and the living.

Methods

Fourteen autopsy subjects, five female, aged 63–89 years were examined. Their hospital records were searched for evidence of any spinal pathology. Permission to perform the autopsies was obtained from the relatives. The study was approved by the Ethics Committee of the Faculty of Medicine, University of Linköping.

Percutaneous epiduroscopy was performed with a few modifications to the method described earlier.[18] The subject was placed in the left lateral position. The epidural space was located at the L_{3-4} interspace using an 18-gauge Tuohy needle and loss of resistance to air, and the distance from the skin recorded. A rigid needle arthroscope, the Olympus Selfoscope 2211 S, with an external diameter of 2.2 mm and with the lens directed 90° to the length of the endoscope, was introduced percutaneously into the epidural space at the L_{2-3} interspace, and the space visually identified. The Tuohy needle was then advanced so that its orifice, directed cephalad, was seen to lie entirely in the space; it was then further advanced to contact the dura mater. The distances from the point of loss of resistance to these two positions were measured. The risk of puncture of the dura mater with further advancement of the needle was judged by the appearance of the dura mater as the needle pressed against it and determined as imminent (+ +), possible (+) or none (−).

After retraction of the midline needle towards the ligamentum flavum, another Tuohy needle of the same size was introduced by way of the paramedian approach, about 1.5 cm lateral to the caudal part of the spinous process of L_4 and directed towards the midline of the epidural space in L_{3-4}. The distance from the skin to the point of loss of resistance was measured. This needle was then also advanced first so that its orifice, again directed cephalad, was seen to be entirely in the space and then further to contact the dura mater. The distances from the point of loss of resistance to these two positions were measured. The risk of puncture of the dura mater with further advancement of the needle was judged by the appearance of the dura in the same manner as with the midline needle.

Both needles were then placed just inside the ligamentum flavum with the orifice directed cephalad. An epidural catheter (Vygon, polyamide, external diameter 1.0 mm) was introduced through the midline needle. The extent of tenting of the dura by the tip of the catheter was noted and determined as considerable (+ +), moderate (+) or none (−). The initial course of the catheter was observed as it was advanced gradually 30 mm into the epidural space. The catheter was then retracted. The same procedure was repeated with a catheter through the paramedian needle.

A needle with a diameter of 1.4 mm was introduced into the subarachnoid space at the L_{1-2} or T_{12}–L_1 interspace, after these manoeuvres, and the CSF pressure measured in centimeters in a graduated plastic tubing manometer. The zero line was determined as a straight line through the spinous processes equivalent to the midline. Saline was then injected until the pressure was raised to 1.0 kPa and, if leaks were present, repeated to maintain the pressure. The procedure with advancement of needles to the dura mater,

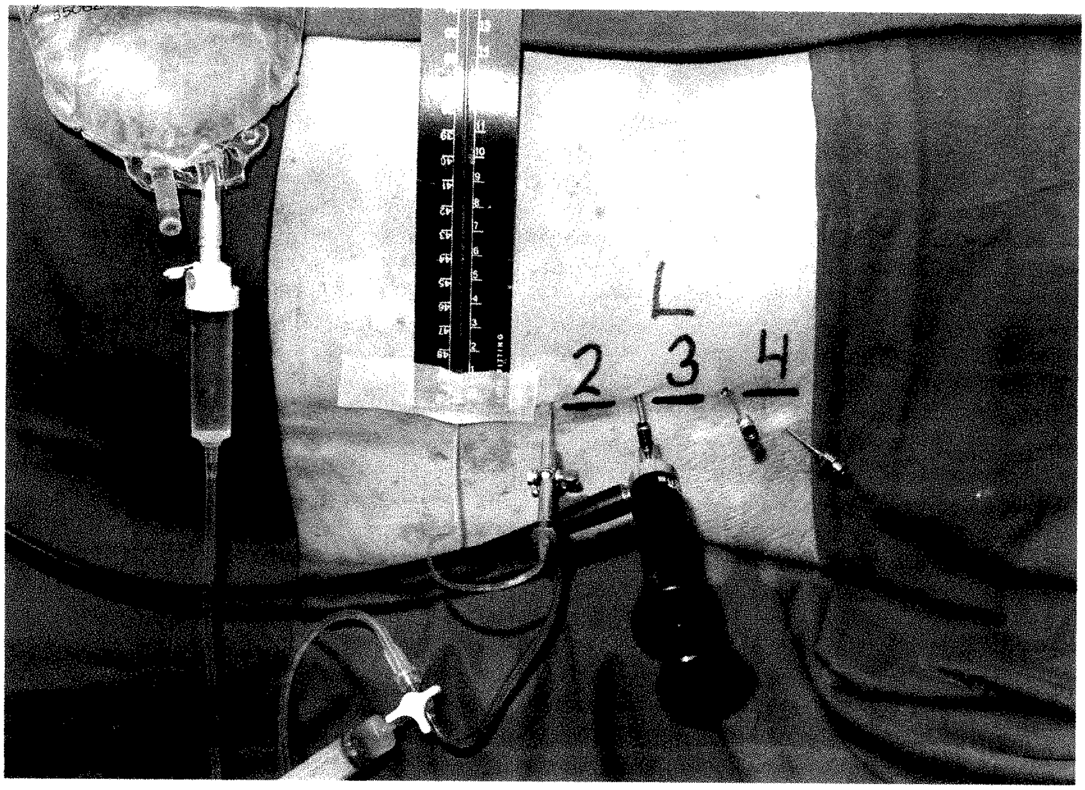

Fig. 1. Epiduroscopy experiment in autopsy subject. From left to right: needle for subarachnoid puncture with CSF pressure measurement; the Selfoscope 2211 S; 18-G Tuohy needle in midline of L_{3-4}; and 18-G Tuohy needle with paramedian approach towards L_{3-4}. (Photo: B. Bergenrup).

Table 1. Comparison of midline and paramedian approaches with epiduroscopy in 14 autopsy subjects.

Column	1		2		3		4	5		6		7			8		
	Distance						Needle angle — Midline paramedian	Risk puncture of dura				Midline catheter			Paramedian catheter		
	Skin to loss of resistance (CSF 0–0.3)		Loss of resistance to dura (CSF 0–0.3)		Change distance to dura (CSF 1.0)		Dorsal plane/ sagittal plane	Midline needle		Paramedian needle		Tenting of dura mater		Course CSF 0–0.3 — CSF 1.0	Tenting of dura mater		Course CSF 0–0.3 — CSF 1.0
Case number	M	P	M	P	M	P		CSF 0–0.3	CSF 1.0	CSF 0–0.3	CSF 1.0	CSF 0–0.3	CSF 1.0		CSF 0–0.3	CSF 1.0	
1	44	53	3	13	0	−2	90°/0°	++	++	−	−	++	++	Turn left	−	−	Straight cephalad
							130°/15°							Turn left			Straight cephalad
2	43	52	5	6	−1	−1	95°/0°	++	++	+	+	+	++	Turn left	−	−	Straight cephalad
							120°/20°							Straight cephalad			Straight cephalad
3	42	54	7	8	−2	0	95°/0°	++	++	−	−	++	++	Turn left, loop	−	−	Straight cephalad
							130°/25°							Turn right			Straight cephalad
4	52	60	4	6	−4	−1	95°/0°	++	++	−	−	++	++	Straight cephalad	−	−	Straight cephalad
							120°/20°							Straight cephalad			Straight cephalad
5	43	61	1	6	0	0	90°/0°	++	++	−	−	++	++	Turn left, loop	−	−	Straight cephalad
							130°/25°							Straight cephalad			Straight cephalad
6	51	60	1	9	−1	−1	90°/0°	++	++	−	−	++	++	Turn left, loop	−	−	Straight cephalad
							130°/25°							Turn left			Straight cephalad
7	54	60	2	5	0	0	95°/0°	++	++	−	−	+	+	Straight cephalad	−	−	Straight cephalad
							120°/25°							Straight cephalad			Straight cephalad
8	51	56	2	6	−2	−2	90°/0°	++	++	−	−	+	+	Turn left	−	−	Straight cephalad
							135°/20°							Turn left			Straight cephalad
9	56	67	2	5	0	0	100°/0°	++	++	++	++	++	++	Turn caudad	−	−	Straight cephalad
							125°/15°							Turn caudad			Straight cephalad
10	48	61	4	7	0	0	95°/0°	++	++	−	−	++	++	Straight cephalad	−	−	Straight cephalad
							130°/20°							Turn left			Straight cephalad
11	45	52	7	13	0	−1	100°/0°	++	++	++	++	++	++	Straight cephalad	−	−	Straight cephalad
							130°/15°							Turn left			Straight cephalad
12	54	61	6	7	−1	−2	100°/0°	++	++	−	−	++	++	Turn right	−	−	Straight cephalad
							120°/15°							Turn right			Straight cephalad
13	49	56	4	6	−1	0	95°/0°	++	++	−	−	++	++	Turn left, loop	−	−	Straight cephalad
							130°/15°							Turn left, loop			Straight cephalad
14	49	58	6	9	−1	−2	100°/0°	++	++	−	−	+	+	Turn left, loop	−	−	Straight cephalad
							120°/20°							Turn left			Straight cephalad

Distances in millimeters. CSF pressures in kPa. M = Midline; P = Paramedian. Risk puncture of dura mater: ++, imminent; +, possible; −, no risk. Tenting of dura mater: ++, great; +, moderate; −, no tenting. Comparison of paramedian with midline approach with regard to the risk of dural puncture, tenting and course of catheter by one-tailed sign tests reveals statistically significant differences in all cases with $p < 0.001$ at the initial as well as the raised CSF pressure.

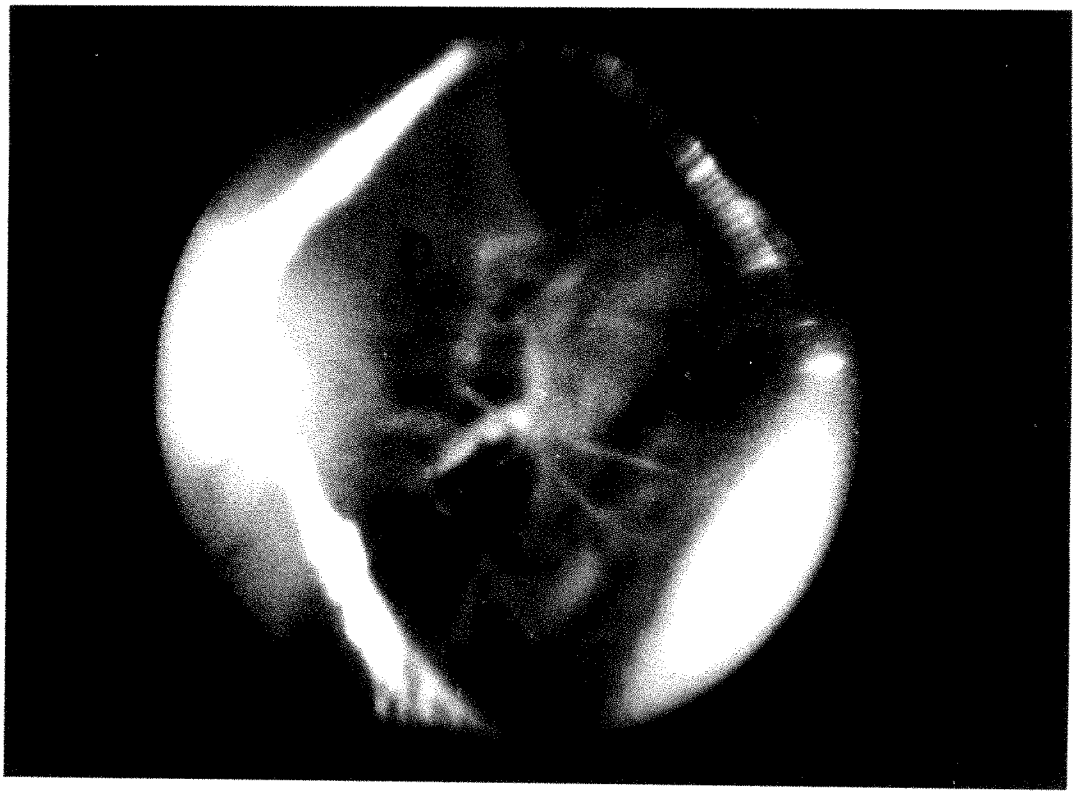

Fig. 2. Epiduroscopy (case 8). Caudad view of dura mater (D) and flaval ligaments (F). They are joined by the dorsomedian connective tissue band in the centre. The epidural catheter is passed through the midline needle 20 mm into the epidural space. Only 4–5 mm of it can be seen as it deviates to the left part of the space and disappears (arrow). (CSF 0 kPa). (Photo: R.G. Blomberg).

measurement of the distances to it and introduction of catheters was then repeated. Finally, the angles of each needle to the dorsal plane of the skin and to the sagittal plane were measured. The experimental situation is illustrated in Fig. 1. Needle positions and catheter courses were documented by photography. Statistical analyses were made by one-tailed sign tests.

Results

The initial CSF pressure was zero in all cases but one (number 2) where it was 0.3 kPa. A prominent dorsomedian connective tissue band was seen in each subject; in seven cases it was very dense. An evident dorsomedian fold of the dura mater was found in each subject.

Detailed results are presented in Table 1. The distance from the skin to the point of loss of resistance (column 1) was an average 48.6 mm (range 42–56 mm) for the midline needle and for the paramedian needle 57.9 mm (range 52–67 mm). The paramedian needle was passed an average 9.3 mm (range 5–18 mm) further than the midline needle to reach the epidural space. It was necessary to pass the midline needle an average 2.4 mm (range 0–5 mm) and the paramedian needle 3.4 mm (range 0–9 mm) from the point of loss of resistance before the orifice could be seen to lie entirely in the epidural space. The distance from the point of loss of resistance to contact with the dura mater by the needle was an average of 3.9 mm (range 1–7 mm) for the midline needle and for the paramedian needle 7.6 mm (range 5–13 mm) at the initial CSF pressure (column 2). The paramedian needle was thus advanced an average 3.7 mm (range 1–10 mm) further than the midline needle in the epidural space to reach the dura mater. Distance was reduced an average 1.0 mm for both needles (range 0–4 mm, the same for both needles, column 3), when CSF pressure was raised to 1.0 kPa.

The cephalad angle of the midline needle to the dorsal plane of the skin varied between 90° and 100°. The position of the needle was by definition in the sagittal plane. The cephalad angle of the paramedian needle varied between 120° and 135°. The angle of it to the sagittal plane was between 15° and 25° (column 4). The midline needle presented an imminent risk of perforating the dura mater in all 14 subjects if advanced further from the point of contact. Only two of the paramedian needles presented an imminent risk of perforation of the dura mater and in one other case the risk was judged to be possible. CSF pressure increase to 1.0 kPa did not change these relationships (columns 5 and 6).

The tip of the catheter introduced through the midline needle caused considerable tenting of the dura in 10 subjects and moderate tenting in four. The degree of tenting was unchanged, when the CSF pressure was raised to normal, except in one case (number 2), where it increased from moderate to great. The tip of the paramedian catheter did not cause tenting in any case, regardless of the CSF pressure.

The midline catheter took a varying course. Initially, it was straight cephalad in four of the 14 subjects. It deviated laterally in two of these when the CSF pressure was increased and in two it stayed straight cephalad. One of the remaining 10 catheters turned caudad and nine deviated laterally at the initial CSF pressure (Fig. 2). Five of these turned up in a loop as the tip of the catheter caught on

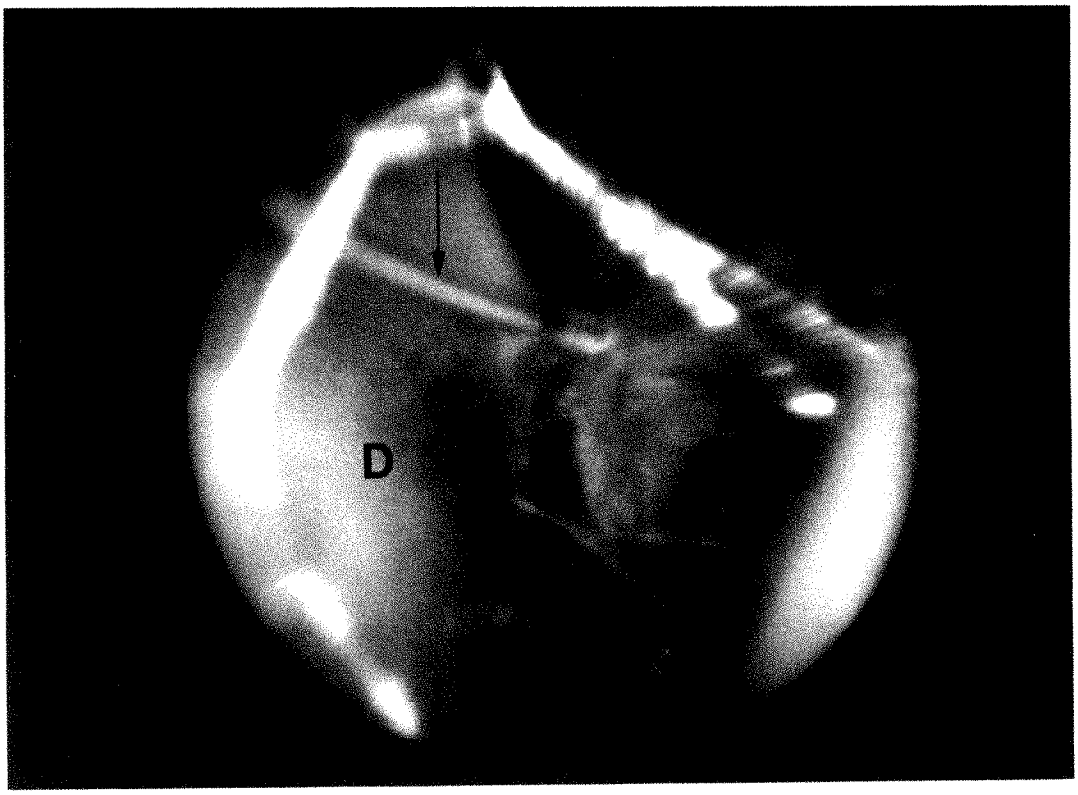

Fig. 3. Epiduroscopy (case 8). The epidural catheter, passed through the paramedian needle 20 mm into the space, demonstrates a straight cephalad course (arrow). (CSF 0 kPa). (Photo: R.G. Blomberg).

strands of connective tissue. Only two of these 10 catheters changed to a straight cephalad course as the CSF pressure was increased. The paramedian catheter was passed easily on a straight cephalad course without any resistance in all of the 14 subjects (Fig. 3). Its route was unchanged when the CSF pressure was increased to normal (Table 1, columns 7 and 8).

Comparison of the paramedian approach with the midline approach with regard to the risk of dural puncture, tenting, and the course taken by the catheter revealed a statistically significant difference in all cases, $p < 0.001$. The tests were performed as one-tailed sign tests at the initial as well as at the increased CSF pressure.

Hospital records did not reveal evidence of spinal pathology in any of the subjects.

Discussion

Some technical aspects of epiduroscopy require discussion. The presence of the dorsomedian connective tissue band will tend to impede vision. It was necessary in some of the cases, in order to obtain an adequate view, to break up carefully part of the strands of connective tissue, for example by pushing the endoscope against the dura mater. However, a condition for inclusion of the subject in this study was that the dorsomedian connective tissue band was intact at the L_{3-4} level throughout the whole examination.

Many technical problems may be encountered during the procedure, among which leakage of blood from damaged vessels and CSF from the subarachnoid puncture are examples. Such factors could make a complete examination impossible. Thus, 29 subjects were studied in order to obtain the total of 14 successful examinations reported here.

Measurement of distances was achieved by subtraction from the total needle length the part above the skin's surface. A source of possible error was the reduced elasticity of the skin and subcutaneous tissues of the autopsy subject, which necessitated extra checking of the measurements. The situation in the cadaver is not exactly representative of the epidural space *in vivo* and hence it must be emphasised that the distances reported here cannot be transferred directly to the situation of clinical epidural anaesthesia. The presence of a patent circulation can be expected to reduce even further the space available for epidural opening, as indicated by the preliminary results of epiduroscopy in the living patient.[17]

The paramedian needle was passed a greater distance than the midline needle both in order to reach the epidural space as well as to obtain contact with the dura mater. This is a consequence of the greater cephalad angle to the dorsal skin plane, which is assumed to represent the plane of the dura mater even if it is not exactly equivalent to it. Both needles were sometimes passed a distance that was greater than the length of the orifice, 2.0 mm, from the point of loss of resistance to the point where the orifice was seen to lie entirely in the epidural space. One explanation is that the connective tissue in the dorsal aspect of the epidural space covering the vertebrae and ligamentum flavum[19] in some subjects was very rich in fat and created a fairly thick but soft barrier through which the needle had to pass. Strands of connective tissue could impede vision so that the needle had to be advanced past them before its orifice could be seen. Also, when the needle's orifice was not placed exactly in the midline the distance could be increased slightly.

Determination of the risk of dural puncture with further advancement of the needle would, of course, best have been achieved by letting the needle perforate the dura. This would have destroyed the experimental situation so it was necessary instead to estimate from the appearance of the dura mater. This did not present any difficulties.

The risk of puncture of the dura mater with further advancement of the needle was imminent, because the bevel of the midline needle was brought into contact with the dura mater almost at a right angle. An important factor was the relative immobility of the dura mater caused by the dorsomedian connective tissue band. In contrast, the greater cephalad angle of the paramedian needle brought the bent part of the needle tip into contact with the dura mater, bluntly pushing the dura away from the dorsal aspect as much as its mobility would permit. The risk of puncture of the dura mater with further advancement of the paramedian needle was thus very low compared with that of the midline needle both at the initial as well as at the normal CSF pressure. In several subjects it was even possible to continue to advance the paramedian needle past the point of initial contact with the dura without any risk of perforation arising. The three cases of imminent or possible risk of dural puncture with the paramedian needle all demonstrated a very dense dorsomedian connective tissue band, which strongly restricted dura mater movement and caused a fold against which the needle pressed.

The differences in angle to the dura mater also influenced the tenting caused by the tip of the epidural catheter. The midline catheter with an entry into the space from the needle almost at right angles was thus associated with considerable dural tenting. On the other hand, no tenting was caused by the tip of the paramedian catheter which entered from the needle at an angle of 120°–135° and thus easily slid off the dura mater.

The course of the midline catheter was unpredictable since contact with the dura caused variable deviations. Strands of connective tissue that restricted movement of the dura mater in the region of catheter contact contributed to this behaviour. A loop was seen to be formed when the tip caught on connective tissue strands, as the catheter was advanced. At a normal CSF pressure the catheter changed to a straight cephalad course in only two instances, while a straight course was changed into a deviated one in two other cases. In contrast, the paramedian catheter was advanced easily in a straight cepahalad direction without any resistance in all 14 cases. Even in the subjects with a dense dorsomedian connective tissue band, no obstacle was presented to the paramedian catheter, which passed through the strands and advanced parallel to the dorsomedian fold of the dura mater.

Radiographic studies of epidural catheters[10–14] have demonstrated a great variation in the course of a midline catheter. In a study by Barreto *et al.*[15] 13 catheters introduced with the paramedian approach and examined by radiography all took a straight cephalad direction. The results of this present study agree with these reports.

The clinical reports and statements [1–7] about the proposed mechanisms for the advantages of the paramedian approach pointed to the greater cephalad angle of the paramedian needle as a significant factor. This assumption has been verified by the present study. In addition, the role of the dorsomedian connective tissue band in restricting the mobility of the dura mater was demonstrated as an equally important factor. This was particularly pertinent to the potential of the midline needle and catheter to cause accidental dural puncture and a divergent catheter course.

Clinical comparisons between midline puncture and the paramedian approach in obstetric analgesia were made in a prospective study by Griffin and Scott.[8] The two approaches proved to be equally successful with a similar incidence of complications. On the other hand, a retrospective study by Jaucot[9] in obstetrics indicated a greater frequency of intravascular cannulation and paraesthesia with midline puncture as the catheter was introduced, in comparison with the paramedian approach; this in turn was associated with an easier catheter insertion. The findings of this present study with regard to the different catheter behaviour under the two techniques, offer an explanation for such variations. The paramedian catheter's straight cephalad course will prevent its contact with lateral areas of the epidural space, which contain large vessels as well as nerve roots.

In summary, this study of autopsy subjects with epiduroscopy has demonstrated the technical advantages of the paramedian approach for lumbar epidural puncture and catheter introduction. These are the low risk of accidental puncture of the dura mater and a tendency for catheters to pass in a straight cephalad direction in contrast to the midline approach. Also, the effects of the dorsomedian connective tissue band have been demonstrated, which show that the restriction in mobility of the dura mater caused by the band will mainly influence the needle and catheter behaviour when midline puncture is used. However, when the band was exceptionally dense, it was shown in three subjects to have contributed to the risk of dural puncture even though the needle was introduced by a paramedian route. It did not, however, affect the straight cephalad course of the paramedian catheter in any of the 14 subjects studied.

Acknowledgments

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References

1. Bonica JJ. Continuous peridural block. *Anesthesiology* 1956; **17:** 626–30.
2. Bromage PR. *Epidural analgesia.* Philadelphia: W.B. Saunders, 1978: 187–8.
3. Carrie LES. The approach to the extradural space. *Anaesthesia* 1971; **26:** 252–3.
4. Armitage EN. The paramedian approach to lumbar epidural analgesia. *Anaesthesia* 1976; **31:** 1287–8.
5. Carrie LES. The paramedian approach to the epidural space. Technique and choice of needle. *Anaesthesia* 1977; **32:** 670–1.
6. Chapman GM. The paramedian approach to the epidural space. Endorsement. *Anaesthesia* 1977; **32:** 671–2.
7. Armitage EN. The paramedian approach to the epidural space. Reply. *Anaesthesia* 1977; **32:** 672.
8. Griffin RM, Scott RPF. A comparison between the midline and paramedian approaches to the extradural space. *Anaesthesia* 1984; **39:** 584–6.
9. Jaucot J. Paramedian approach of the peridural space in obstetrics. *Acta Anaesthesiologica Belgica* 1986; **37:** 187–92.
10. Hehre FW, Sayig JM, Lowman RM. Etiologic aspects of failure of continuous lumbar peridural anesthesia. *Anesthesia and Analgesia* 1960; **39:** 511–7.

11. Sanchez R, Acuna L, Rocha F. An analysis of the radiological visualization of the catheters placed in the epidural space. *British Journal of Anaesthesia* 1967; **39**: 485–9.
12. Bridenbaugh LD, Moore DC, Bagdi P, Bridenbaugh PO. The position of plastic tubing in continuous-block techniques: an X-ray study 552 patients. *Anesthesiology* 1968; **29**: 1047–9.
13. Muneyuki M, Shirai K, Inamoto A. Roentgenographic analysis of the positions of catheters in the epidural space. *Anesthesiology* 1970; **33**: 19–24.
14. Matouskova A, Hanson B, Rösmark U. Continuous mini-infusion of bupivacaine into the epidural space during labor. Part 1: Radiographic visualization of the epidural catheters. *Acta Obstetrica et Gynecologica Scandinavica* 1979; **83** (Suppl.): 15–29.
15. Barretto C, Hook R, Seah CH. Use of the Tuohy needle in paramedian approach for peridural block. *Anesthesia and Analgesia* 1977; **56**: 582–4.
16. Blomberg R. The dorsomedian connective tissue band in the lumbar epidural space of humans. An anatomical study using epiduroscopy in autopsy cases. *Anesthesia and Analgesia* 1986; **65**: 747–52.
17. Blomberg RG, Olsson S. Epiduroscopy—endoscopy of the epidural space in man. *Acta Anaesthesiologica Scandinavica* 1987; **86** (Suppl.): 178.
18. Blomberg R. A method for epiduroscopy and spinaloscopy. Presentation of preliminary results. *Acta Anaesthesiologica Scandinavica* 1985; **29**: 113–6.
19. Covino BG, Scott DB. *Handbook of epidural anaesthesia and analgesia*. Copenhagen: Schultz Medical Information, Orlando, Florida: Grune and Stratton, 1985: 16.

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Lignocaine 2% with adrenaline for epidural Caesarean section

A comparison with 0.5% bupivacaine

A. C. NORTON, A. G. DAVIS AND R. J. SPICER

Summary

A randomised double blind controlled trial of freshly prepared 2% lignocaine with 1/200 000 adrenaline and 0.5% plain bupivacaine was conducted on 60 women undergoing elective Caesarean section. The use of the former enabled epidural blockade to above the T_6 dermatome to be established in a significantly shorter time than with bupivacaine ($p < 0.005$). The quality of sensory blockade and incidence of complications was similar in the two groups. The solutions were of similar potency as measured by the volume required per segment blocked. Motor blockade was more intense with 2% lignocaine with adrenaline ($p < 0.03$). More neonates had moderately depressed Apgar scores (5–7) at one minute in the lignocaine group but this difference was not statistically significant, and there was no difference in the distribution of Apgar scores at 3 minutes. Lignocaine with 1/200 000 adrenaline is a useful alternative to 0.5% plain bupivacaine when it is desired to establish rapidly epidural blockade for Caesarean section.

Key words

Anaesthesia; obstetric.
Anaesthetics, local; bupivacaine, lignocaine.

Regional blockade offers advantages over general anaesthesia for Caesarean section. The Maternal Mortality Report for Scotland[1] for the 1976–80 quinquennium recommends that the use of general anaesthesia be kept to a minimum and regional anaesthesia used wherever possible. Epidural anaesthesia is associated with better early neonatal condition and higher Apgar scores than general anaesthesia.[2,3] Other advantages include the opportunity for maternal bonding and avoidance of the hazards of general anaesthesia including the possibility of unintentional awareness.

Plain bupivacaine 0.5% is the current drug of choice for epidural anaesthesia for Caesarean section.[4] Bupivacaine 0.75% has been withdrawn from obstetric use. The main disadvantage of bupivacaine is the slow onset of action and time required to obtain the necessary block between the T_6 and S_5 dermatomes. The 'two-stage' top-up technique described by Thorburn and Moir[5] reduces the incidence of inadequate blockade to around 2% whereas high failure rates have been reported previously.[6] The top-up protocol chosen for this study was the preferred method to establish epidural blockade for Caesarean section amongst the Consultant staff of the Southern General Hospital. Dutton *et al.*[4] report that 35% of patients who undergo epidural Caesarean section with 0.5% bupivacaine required supplementary analgesia. This randomised double blind controlled trial was designed to assess the comparative characteristics of 2% lignocaine with adrenaline 1/200 000 for epidural Caesarean section, and in particular whether adequate blockade could be established more rapidly than with 0.5% bupivacaine and whether the quality of blockade with bupivacaine could be improved upon.

Methods

The study was carried out on 62 patients who were to undergo epidural Caesarean section. Patients gave informed consent to a trial protocol approved by the local ethics committee. The exclusion criteria for the trial were failure to consent to epidural Caesarean section, contraindication to epidural section, analgesia or sedation already given, presence of a pre-existing epidural and failure to follow the trial protocol. Two Caesarean sections performed were excluded from further analysis, one because the protocol was not followed and the other because an emergency case caused a long delay in an elective patient, which necessitated further epidural top-ups.

The patients were allocated by means of a computer generated randomisation code to receive either 0.5% plain bupivacaine or 2% lignocaine with adrenaline 1/200 000.

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One of the two trial organisers (A.C.N. or R.J.S.) prepared 40 ml of the trial solution in an aseptic fashion into 50 ml syringes according to the randomisation code. These syringes were identified only by a trial number and the words 'local anaesthetic'. In order to avoid excessively low pH and significant amounts of preservatives the lignocaine syringes were prepared from 20-ml autoclaved ampoules of preservative-free 2% lignocaine hydrochloride to which 0.2 ml of 1/1000 adrenaline solution was added to 40 ml of local anaesthetic.

All patients were premedicated with ranitidine 150 mg orally 2 hours before operation. An intravenous cannula was sited and the circulation preloaded with 1000 ml of Hartmann's solution. An epidural was then positioned in the $L_{2/3}$ interspace with an 18-gauge Tuohy needle. The top-up protocol was started once the catheter had been sited and secured. No test doses were given. Ten millilitres of local anaesthetic solution was given with the mother in a left tilt on a wedge. Five minutes after the first injection, the mother was turned to a right tilt and a further 10 ml of local anaesthetic could be given. The doses could be scaled down to 8 ml each side for patients of short stature. The anaesthetist who performed the epidural could give further top-ups in any posture required to achieve bilateral block to T_6 or higher.

Observations of left and right sided sensory and motor blockade were made at 5-minute intervals from 10 minutes after the first injection of local anaesthetic. The time of onset of blockade was defined as the time from first injection to the time when sensory blockade was bilaterally T_6 or higher. Quality of sensory blockade was graded intraoperatively using a 4-point scale: Grade 1, procedure totally painless; 2, mild discomfort or pain not causing distress; 3, discomfort causing distress but not necessitating alternative anaesthesia; 4, inadequate blockade, alternative anaesthesia required. The usage of supplementary analgesia and sedation was also recorded.

Motor blockade was measured by means of a four-point scale: 0, no leg weakness; 1, mild weakness, able to lift foot off the bed; 2, moderate weakness, able to slide foot up the bed; 3, severe weakness, unable to slide foot up the bed. Assessment of motor blockade was performed at 5-minute intervals pre-operatively, at the end of surgery and 1, 2 and 4 hours after operation.

Arterial blood pressure was measured every 5 minutes before and during surgery using a sphygmomanometer, and observed recordings were graded on a three-point scale: Grade 0, lowest systolic pressure 100 mmHg; 1, mild hypertension, lowest systolic pressure $\geqslant$ 90 mmHg; 2, significant hypotension, lowest systolic pressure $<$ 90 mmHg. The use of ephedrine to maintain blood pressure was also recorded.

Duration of epidural blockade was assessed by recording the time that the patients first noted wound pain and received postoperative analgesia. The patients had open access to intramuscular papaveretum and were encouraged to ask for analgesia as soon as they felt it necessary. Objective assessment of duration of blockade was made by noting the time after first injection of local anaesthetic at which blockade on either side had regressed to a segmental level of T_{10} or lower. The patients were asked to indicate their level of pain on a 10-cm visual analogue scale which ranged from 'no pain at all' to 'worst pain imaginable', in order to attempt to assess the level of postoperative pain perceived by the patients in the early period after operation. Visual analogue pain scores were obtained at 1, 2 and 4 hours after the end of surgery.

Early neonatal condition was assessed by means of Apgar scores recorded at 1 and 3 minutes by the attending paediatrician. The mothers were visited in the 24–48 hours after operation and asked whether they would undergo epidural Caesarean section again and were given an opportunity to express any comments on their experiences.

Statistics. Results were analysed by an Amstrad 6128 microcomputer (Amstrad Consumer Electronics PLC) running the Amstat 1 and 2 statistical packages for parametric and nonparametric statistics. Tests employed were one-way analysis of variance and calculation of F ratio, Student's *t*-test, Chi-squared test with Yates' correction where appropriate and the Mann–Whitney *U* test.

Results

Details of the mean ages, weights, heights of the patients and indications for Caesarean section are given in Table 1.

Onset and duration of blockade (Table 2). The time taken to establish sensory blockade from the perineum to a sensory level of T_6 or higher was statistically significantly faster in the lignocaine group ($p < 0.005$). Onset and offset times tended to conform to log normal distributions and statistics are therefore performed on logarithmically transformed data. The duration of action of 2% lignocaine with 1/200 000 adrenaline was statistically significantly shorter than that of 0.5% bupivacaine both in terms of timing of first postoperative analgesia (mean 201 versus 280 minutes) and the times that the patients gave as experiencing wound pain after operation (mean 173 versus 225 minutes). The duration of action of 2% lignocaine with adrenaline was in all cases adequate to complete the planned surgery.

Quality of sensory blockade (Table 3). No block was inadequate to the extent that general or spinal anaesthesia was required. There was no significant difference in the quality of analgesia achieved. A subjective scoring system for analgesia was preferred by the investigators rather than grading blocks by supplementary analgesics given. It was

Table 1. Patient details and indications for operation. Values expressed as mean (SEM).

	Age (years)	Weight (kg)	Height (cm)	Breech	Twins	CPD previous section	Placenta praevia	Other
Lignocaine 2% plus 1/200 000 adrenaline (n = 30)	28.5 (0.8)	76.1 (2.7)	160.3 (1.4)	12	1	11	1	5
Bupivacaine 0.5% (n = 30)	30.9 (1.0)	71.6 (2.4)	157.5 (1.3)	10	2	14	1	3

No significant differences. CPD, suspected or proven cephalopelvic disproportion.

Table 2. Onset and duration of blockade. Values expressed as mean (95% confidence limits) [SD].

	Onset to $> T_6$ (minutes)	Log_{10} onset time	Block regression to T_{10} (minutes)	Log_{10} regression T_{10}	Time of reporting wound pain (minutes)	Log_{10} wound pain time	Time of first postoperative analgesic (minutes)	Log_{10} postoperative analgesic time
Lignocaine 2% 1/200 000 adrenaline ($n = 30$)	22.4 (19.1–25.7) [8.83]	1.32*** (1.25–1.38) [0.17]	170.6 (152.6–188.6) [44.4]	2.22* (2.18–2.26) [0.11]	172.9 (155.2–190.6) [46.6]	2.22* (2.18–2.27) [0.12]	200.6 (178.5–222.7) [58.2]	2.28** (2.23–2.33) [0.13]
Bupivacaine 0.5% ($n = 30$)	30.6 (25.7–35.6) [13.24]	1.45 (1.38–1.52) [0.17]	216.2 (182.7–249.7) [81.2]	2.30 (2.23–2.37) [0.17]	224.6 (195.3–253.9) [75.6]	2.32 (2.26–2.39) [0.17]	279.8 (236.1–323.5) [114.8]	2.41 (2.33–2.48) [0.20]

* $p < 0.05$
** $p < 0.01$ 1-way analysis of variance.
*** $p < 0.005$

Table 3. Sensory grading and supplementary analgesia.

Grade	Lignocaine 2% plus adrenaline: Number of patients	Lignocaine 2% plus adrenaline: Number who received supplements	Bupivacaine 0.5%: Number of patients	Bupivacaine 0.5%: Number who received supplements
1	17 (56.7%)	4	15 (50%)	3
2	11 (36.7%)	9	10 (33.3%)	6
3	2 (6.7%)	2	5 (16.7%)	5
4	0	0	0	0
Totals	30	15	30	14

No significant difference, Chi-squared test.

Table 4. Comparison of doses and volumes of local anaesthetic used to achieve adequate blockade. Values expressed as mean (SEM).

	Dose (mg)	Volume (ml)	Required ml per segment blocked	Number of supplementary top-ups required after initial two doses (number of patients)				
				0	1	2	3	4
Lignocaine 2% plus adrenaline	502.6 (16.0)	25.1 (0.8)	1.37 (0.13)	8	15	7	0	0
Bupivacaine 0.5%	129 (4.0)	25.8 (0.8)	1.49 (0.15)	7	17	3	2	1

Table 5. Maximum motor blockade.

		Lignocaine	Bupivacaine
Grade	0	0	0
of	1	0	4 (13.3%)
motor	2	3 (10%)	7 (21.3%)
block	3	27 (90%)	19 (63.3%)

$p < 0.03$. Chi-squared test, df = 2.

considered that the need for supplementary analgesics did not always represent inadequate epidural blockade but factors such as anxiety, lack of ease on an unyielding operating table and the discomfort of dense motor blockade. The frequency with which supplementary analgesia was given was not significantly different and a high degree of satisfaction was reported by both groups of patients in follow-up interviews.

Dose of drug required to achieve adequate blockade (Table 4). Doses of drug administered are not directly comparable, but the volumes of solution required to achieve the spread required were similar. The number of blocks achieving a maximum sensory level above T_4, which we regard as the maximum desirable height of epidural blockade for Caesarean section in order to minimise the risks of cardiac sympathetic blockade, excessive hypotension and the possibility of respiratory embarrassment, were the same in each treatment group (lignocaine 14, bupivacaine 14). The volume required per segment blocked above the height of injection (L_2) were not significantly different, which indicated that 2% lignocaine with adrenaline and 0.5% bupivacaine are solutions of similar potency for epidural Caesarean section. The number of top-ups required in addition to the initial doses in left and right tilt are also shown in this table. No patient in the lignocaine group required more than two supplementary top-ups, whereas in the bupivacaine group, two patients required three and one patient required four top-ups.

Motor blockade (Table 5). Lignocaine 2% with adrenaline was associated with more intense maximum motor blockade ($p < 0.03$). Of the lignocaine group, 90% exhibited severe weakness.

Complications (Table 6). There was no statistically significant difference in the frequency of hypotension recorded, however seven patients who received bupivacaine had a lowest arterial blood pressure of less than 90 mmHg whereas only three of the lignocaine group had similar degrees of hypotension. This difference was not statistically significant. The number of patients who received ephedrine

Table 6. Complications of epidural blockade.

		Lignocaine 2% plus adrenaline		Bupivacaine 0.5%	
		Number of patients	Patients who received ephedrine	Number of patients	Patients who received ephedrine
Hypotension	> 100	18 (60%)	0	15 (50%)	0
(lowest	⩾ 90	9 (30%)	6	8 (26.6%)	4
systolic BP)	< 90	3 (10%)	3	7 (23.3%)	6
Urinary	0	18 (60%)		16 (53.3%)	
retention—	1	11 (36.6%)		11 (36.6%)	
number of	2	0 (0%)		2 (6%)	
catheterisations	2+	1 (3%)		1 (3%)	

No significant differences, Chi-squared test.

Table 7. Postoperative visual analogue pain scores. Values expressed are mean (95% confidence limits).

	Lignocaine	Bupivacaine	
1 hour	2.00	0.82	*
	(0.8)	(0.55)	
2 hours	3.53	2.87	NS
	(1.09)	(1.25)	
4 hours	3.95	4.15	NS
	(1.93)	(1.47)	

* $p < 0.01$, Mann Whitney *U* test.

Table 8. Willingness to undergo repeat epidural section.

	Sensory grade	Yes		No	Unsure/ unknown
Lignocaine 2% plus adrenaline	1	16	86.7%	0	1
	2	9		1	1
	3	1		0	1
Bupivacaine 0.5%	1	14	76.7%	1	0
	2	8		0	2
	3	1		2	2

Table 9. Neonatal weights, gestational age and Apgar scores.

	Gestational age, weeks* mean, (SD)	Birth weight, kg* mean, (SD)	Apgar at 1 minute†			Apgar at 3 minutes†		
			0–4	5–7	8–10	0–4	5–7	8–10
Lignocaine 2% plus adrenaline ($n = 31$)	37.6 (1.84)	3.04 (0.42)	0	8	23	0	1	31
Bupivacaine 0.5% ($n = 32$)	37.4 (2.00)	3.13 (0.53)	0	5	27	0	0	32

* No significant difference, *t*-test.
† No significant difference, Chi-squared test.
(There was a pair of twins in the lignocaine group and two pairs in the bupivacaine group).

for treatment of hypotension was similar in each treatment group (bupivacaine 10, lignocaine 9). Urinary retention was assessed by the number of catheterisations made in the postoperative period (no indwelling catheters were inserted). There was no significant difference in the two treatment groups.

Postoperative pain scores (Table 7). Mean postoperative pain scores were higher in the lignocaine group at one hour after operation. Measurement of sensory level to pinprick sensation showed that at one hour postoperatively the block had regressed to T_{10} or lower in nine of the lignocaine group and three of the bupivacaine group. There was a very wide range of variability in the degree of pain experienced after operation in both groups. In the lignocaine group, 28 (93.3%) mothers had received analgesia by 4 hours postoperatively, while only 17 (56.6%) of the bupivacaine group had done so.

Patient satisfaction (Table 8). Follow-up interviews of the mothers revealed a generally high level of satisfaction. Four in the lignocaine group who had had a previous epidural Caesarean section with bupivacaine commented on the denser motor blockade they perceived with lignocaine, but also commented favourably on the earlier offset of effect as it allowed them earlier ambulation. These patients were all ambulant 6–8 hours after operation.

Apgar scores (Table 9). Apgar scores were measured by the paediatrician who was unaware which local anaesthetic was employed. A higher, but not statistically significant difference in the frequency of moderately depressed Apgar scores at one minute was noted in the lignocaine group. The two patient populations were similar in terms of indication for Caesarean section, gestational age and birth weight. None of the neonates required tracheal intubation or ventilation.

Discussion

Previous reports of etidocaine for lower abdominal surgery[7–9] have demonstrated its rapid onset and prolonged duration of sensory and motor blockade in high concentration. The quality of sensory blockade achieved was poor, with an overall failure rate of 20% when used in 1.5% solution with adrenaline 1/200 000 for Caesarean section.[4] This present study demonstrates that the use of 2% lignocaine with adrenaline 1/200 000 allows blockade to be established more rapidly than with bupivacaine, without any sacrifice in the quality of anaesthesia; indeed there was a small, but statistically insignificant decrease in the frequency of poor quality (grade 3) blocks with lignocaine.

Conflicting evidence exists as to whether the addition of adrenaline to bupivacaine will decrease the latency of onset. Moir *et al.*[10] found reduction of latency of onset and little effect on quality of analgesia. Sinclair and Scott,[11] using 0.75% bupivacaine in gynaecological surgery, found that the latency was reduced by addition of adrenaline. The duration of subjective analgesia was also increased but there appeared to be no effect on four segment block regression. The addition of adrenaline to bupivacaine for epidural Caesarean section does not appear to be commonly practised.

The use of 2% plain lignocaine for Caesarean section has been associated with relatively high rates of inadequate analgesia which necessitated general anaesthesia; 6 out of 23 patients in one series.[12] A small double-blind trial which compared lignocaine hydrochloride and lignocaine hydrocarbonate without vasoconstrictors did not show any significant difference between the two treatments.[13]

There is some evidence to suggest that the addition of adrenaline to lignocaine administered epidurally increases the density of both sensory and motor blockade.[14] It also reduces the rate of systemic absorption and peak plasma levels of local anaesthetic.[15–17] Fox and Houle[18] demonstrated that 2% lignocaine used with 1/200 000 adrenaline for Caesarean section that maternal (1.39 μg/ml, SD 0.51) and fetal concentrations (0.83 μg/ml, SD 0.35) were relatively low and maternal and fetal outcome were satisfactory.

Commercial preparations of local anaesthetics with adrenaline contain additives such as 0.1% sodium metabisulphite in order to minimise catecholamine oxidation. The pH of such solutions is generally around four as opposed to around seven for plain solutions. The measured pH of sample solutions used in this study was 5.9 for plain 2% autoclaved lignocaine and 5.62 after the addition of 200 μg of adrenaline to 40 ml of 2% lignocaine.

$$\text{As } \log\frac{[\text{cation}]}{[\text{base}]} = \text{pKa} - \text{pH}$$

then reduction of pH reduces the amount of lipid soluble free base and possibly delays the onset of neural blockade.

Freshly prepared 2% lignocaine with adrenaline was therefore chosen for this study for a number of reasons: to reduce the potential for systemic toxicity using a relatively large dose of lignocaine without vasoconstrictor in the epidural space; evidence suggests that adrenaline may increase the intensity of epidural blockade with lignocaine; to avoid problems of autoclave stability of catecholamines; to reduce concentrations of antioxidants such as sodium metabisulphite in the epidural space; to gain the advantage of introducing a local anaesthetic solution that contained adrenaline at a pH closer to the pK of the local anaesthetic used.

A number of papers have investigated possible adverse neonatal neurobehavioural effects of lignocaine. Scanlon *et al.*[19,20] suggested that lignocaine for epidural Caesarean section tended to produce alert but hypotonic babies, while bupivacaine had no adverse effects on neonates. Hollmen *et al.*[21], in a study of delivery under lignocaine 1.5% with 1/200 000 adrenaline epidural anaesthesia or general anaesthesia noted no difference in Apgar scores, but a correlation between weak sucking and rooting reflexes in the first 48 hours of life, which was positively correlated with the incidence of intra-operative hypotension. More recent work by Abboud *et al.*[22] has failed to show any difference in Apgar scores, acid base status or early neonatal behavioural scoring irrespective of whether bupivacaine, lignocaine or chloroprocaine were used for epidural blockade. In a study that compared neonates born under lignocaine epidural anaesthesia and a group of neonates whose mothers had received no analgesics or local anaesthetics during labour or delivery, it was concluded that a mean dose of 446 mg of lignocaine had no effect on early neonatal neurobehavioural scoring.[23] Kileff *et al.*[12] also concluded that 2% lignocaine did not compromise neonatal outcome when used at a mean dose of 586 mg, compared to anaesthesia with bupivacaine. It therefore seems that transient depression of Apgar scores is unlikely to result in adverse neonatal effects when lignocaine is used for epidural anaesthesia for Caesarean section.

We conclude that freshly prepared 2% lignocaine with adrenaline 1/200 000 is a satisfactory alternative to 0.5% bupivacaine for epidural Caesarean section. It offers the advantage of a more rapid onset of blockade without any increase in the incidence of maternal adverse effects and provides a satisfactory level of analgesia. Lignocaine should be used as a freshly prepared solution with adrenaline if it is chosen as the agent to be used for epidural Caesarean section.

References

1. Scottish Home and Health Department. A report on an inquiry into maternal deaths in Scotland 1976–80. HMSO. Edinburgh 1987.
2. James FM, Crawford JS, Hopkinson R, Davies P, Naiem H. A comparison of general anesthesia and lumbar epidural analgesia for elective cesarean section. *Anesthesia and Analgesia* 1977; **56:** 228–35.
3. Fox GS, Houle GL. Acid-base studies in elective caesarian sections during epidural and general anaesthesia. *Canadian Anaesthetists' Society Journal* 1971; **18:** 60–71.
4. Dutton DA, Moir DD, Howie HB, Thorburn J, Watson R. Choice of local anaesthetic drug for extradural Caesarean section. Comparison of 0.5% and 0.75% bupivacaine and 1.5% etidocaine. *British Journal of Anaesthesia* 1984; **56:** 1361–7.
5. Thorburn J, Moir DD. Epidural analgesia for elective Caesarean section. Technique and its assessment. *Anaesthesia* 1980; **35:** 3–6.
6. Milne MK, Murray Lawson JI. Epidural analgesia for Caesarean section. A review of 182 cases. *British Journal of Anaesthesia* 1973; **45:** 1206–10.
7. Lund PC, Cwik JC, Pandanganan RT. Etidocaine—A new long acting local anesthetic agent. A clinical evaluation. *Anesthesia and Analgesia* 1973; **53:** 482–94.
8. Bridenbaugh PO, Tucker GT, Moore DC, Bridenbaugh LD, Thompson GE. Etidocaine—Clinical evaluation for intercostal nerve block and lumbar epidural block. *Anesthesia and Analgesia* 1973; **52:** 407–13.
9. Sinclair CJ, Scott DB. Double blind comparison of 0.75% bupivacaine and 1.5% etidocaine with and without epinephrine in epidural block. *Regional Anaesthesia* 1982; **7:** 77–8.
10. Moir DD, Slater PJ, Thorburn J, McLaren R, Moodie J. Extradural anesthesia in obstetrics: a controlled trial of carbonated lignocaine and bupivacaine hydrochloride with or without adrenaline. *British Journal of Anaesthesia* 1976; **48:** 129–35.
11. Sinclair CJ, Scott DB. Comparison of bupivacaine and etidocaine in extradural blockade. *British Journal of Anaesthesia* 1984; **56:** 147–53.
12. Kileff ME, James FM, Dewan DM, Floyd HM. Neonatal neurobehavioral responses after epidural anesthesia for cesarean section using lidocaine and bupivacaine. *Anesthesia and Analgesia* 1984; **63:** 413–7.
13. Cole CP, McMorland GH, Axelson JE, Jenkins LC. Epidural blockade for cesarean section comparing lidocaine hydrocarbonate and lidocaine hydrochloride. *Anesthesiology* 1985; **62:** 348–50.
14. Bromage PR, Burfoot MF, Crowell DF, Pettigrew RT. Quality of epidural blockade. 1: Influence of physical factors. *British Journal of Anaesthesia* 1964; **36:** 342–52.

15. Braid DP, Scott DB. The systemic absorption of local analgesic drugs. *British Journal of Anaesthesia* 1965; **37**: 394–404.
16. Braid DP, Scott DB. Effect of adrenaline on the systemic absorption of local anaesthetic drugs. *Acta Anaesthesiologica Scandinavica* 1966; **23** (Suppl.): 334.
17. Scott DB, Jebson PJR, Braid DP, Ortengren B, Frisch P. Factors affecting plasma levels of lignocaine and prilocaine. *British Journal of Anaesthesia* 1972; **44**: 1040–9.
18. Fox GS, Houle GL. Transmission of lidocaine hydrochloride across the placenta during Caesarian Section. *Canadian Anaesthetists' Society Journal* 1969; **16**: 135–43.
19. Scanlon JW, Brown WU, Weiss JB, Alper MH. Neurobehavioral responses of newborn infants after maternal epidural anesthesia. *Anesthesiology* 1974; **40**: 121–8.
20. Scanlon JW, Ostheimer GW, Lurie AO, Brown WU, Weiss JB, Alper MH. Neurobehavioural responses and drug concentrations in newborns after maternal epidural anesthesia with bupivacaine. *Anesthesiology* 1976; **45**: 400–5.
21. Hollmen AI, Jouppila R, Kovisto M, Maatta L, Pihlajaniemi R, Puukka M, Rantakyla P. Neurologic activity of infants following anesthesia for caesarean section. *Anesthesiology* 1978; **48**: 350–4.
22. Abboud TK, Kim KC, Noueihed R, Kuhnert BR, Der-Mardirossian N, Moumdjian J, Sarkis F, Nagappala S. Epidural bupivacaine, chloroprocaine, or lidocaine for cesarean section—Maternal and neonatal effects. *Anesthesia and Analgesia* 1983; **62**: 914–9.
23. Abboud TK, Sarkis F, Blikian A, Varakian L, Earl S, Henriksen E. Lack of adverse neonatal neurobehavioural effects of lidocaine. *Anesthesia and Analgesia* 1983; **62**: 473–5.

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Alfentanil infusion in the elderly

Prolonged computer-assisted infusion of alfentanil in the elderly surgical patient

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Summary

The use of a computer-assisted infusion of alfentanil, combined with 66% nitrous oxide in oxygen, for induction and maintenance of anaesthesia was evaluated in 18 elderly patients. The target alfentanil concentration for induction was varied between 300 and 475 ng/ml, to be achieved in 2 minutes. During maintenance, the alfentanil concentration was increased or decreased according to each patient's responses. Arterial blood samples were taken for measurement of alfentanil concentration. There were high incidences of muscle rigidity, bradycardia and hypotension during induction. Hypotension was dose- and concentration-dependent. Signs of light anaesthesia during maintenance were controlled rapidly by increasing the target plasma concentration. Nine patients required naloxone at the end of surgery. Ventilatory depression recurred in three of these. The use of published alfentanil pharmacokinetic data from elderly patients to predict plasma concentrations during prolonged infusion resulted in significant prediction errors, notably in the higher concentration range.

Key words

Analgesics; alfentanil.
Anaesthetic techniques; infusion.

Alfentanil is a synthetic opioid with a quick onset of action because of a rapid blood/brain equilibration, and a short duration of action.[1,2] It has been recommended as a rapid and pleasant induction agent with a minimum of side effects.[3] The pharmacokinetic profile of alfentanil makes it more suitable than other opioids for use by continuous intravenous infusion.[2,4] Continuous infusion of intravenous anaesthetic or opioid agents results in more stable and controllable anaesthesia than intermittent bolus administration, with greater haemodynamic stability, a reduction of the total amount of drug required and a more rapid recovery.[5–7] These advantages of continuous infusion may be important particularly in elderly patients, who have a higher incidence of diseases (such as coronary artery disease, cerebral arteriosclerosis) that can lead to complications during anaesthesia and surgery. It should be emphasised, however, that the elimination half-life of alfentanil is prolonged in elderly patients, as a result of reduced plasma clearance.[8] Thus, infusion regimens based on pharmacokinetic principles must be adapted for use in this population.

The rate of administration of alfentanil by continuous infusion should be adjusted ideally to the patients's requirement, which may alter during the anaesthetic procedure, for instance because of variations in the intensity of surgical stimulation. Variable rate infusion has been shown to provide stable and easily controllable anaesthesia and rapid recovery without postoperative ventilatory depression in young adults.[9,10]

Recently, computer-assisted infusion devices have been developed that offer the possibility of rapidly attaining and maintaining a relatively stable plasma concentration.[11,12] The concentration can be adjusted quickly to match the patients' requirements during surgery.[12] In this study, we investigated the feasibility and haemodynamic effects of a computer-assisted infusion of alfentanil, in combination with nitrous oxide, as an anaesthetic technique for elderly patients.

Methods

Eighteen elderly patients, aged 65–86 years, ASA grades 2 or 3, with normal hepatic and renal function, and scheduled to undergo prolonged elective general surgery, were studied. The study protocol was approved by the University of Leiden Medical Ethics Committee and all patients gave informed consent. Details of the patients and of the operative procedures are given in Table 1.

Premedication was with oral temazepam 10 mg given one hour, and intramuscular atropine 0.25 mg 0.5 hours, before

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Table 1. Details of patients.

Patient no.	Sex	Age (years)	Weight (kg)	Operation	ASA grade
1	M	72	62	Sigmoid resection	2
2	F	80	62	Modified radical mastectomy	3
3	F	72	63	Modified radical mastectomy	2
4	M	65	79	Hemicolectomy	2
5	F	71	59	Pelvic clearance	2
6	F	80	45	Sigmoid resection	2
7	F	68	75	Hysterectomy	3
8	M	66	84	Sigmoid resection	3
9	F	76	64	Sigmoid resection	2
10	M	65	76	Sigmoid resection	3
11	F	66	54	Hemicolectomy	2
12	F	74	77	Hysterectomy	2
13	F	74	64	Cholecystectomy	2
14	F	73	73	Modified radical mastectomy	2
15	F	71	86	Modified radical mastectomy	2
16	M	76	55	Gastric resection	2
17	F	80	65	Modified radical mastectomy	3
18	F	86	67	Gastric resection	3

surgery. Electrocardiogram (ECG) monitoring was started on arrival in the operating room. A 20-gauge catheter was inserted into a radial artery for continuous measurement of arterial pressure and collection of blood samples. Between 300 and 500 ml of 0.9% NaCl solution was infused before induction of anaesthesia. Pancuronium 0.02 mg/kg was given and the patient was pre-oxygenated. The fresh gas inflow was changed after 3 minutes from 100% oxygen to 66% nitrous oxide in oxygen. Simultaneously, an infusion of alfentanil was started.

Alfentanil was administered by a computer-assisted infusion pump (TIAC: Titration of Intravenous Agents by Computer; Janssen Scientific Instruments, Janssen Pharmaceutica, Belgium), programmed with published pharmacokinetic data from elderly patients.[8] These data were determined after an intravenous bolus injection of alfentanil 50 μg/kg in a group of 15 elderly patients who underwent abdominal surgery. The computer (Hewlett-Packard 86) is provided with alfentanil two-compartment pharmacokinetic data; a desired plasma concentration is chosen, and the computer calculates the amount of drug, and the rate of infusion, which the calibrated pump must deliver. The computer uses a BET infusion scheme to achieve the chosen plasma concentration: the initial volume of distribution is filled up by a bolus (B), the eliminated (E) drug is replaced by a maintenance infusion rate, and an exponentially declining infusion rate compensates for the transfer (T) of drug into the peripheral compartment.[13] In this way, the computer calculates every 15 seconds the amount of drug needed to achieve and maintain the chosen plasma concentration, and adjusts the infusion rate accordingly. The chosen plasma concentration may be changed by the user during anaesthesia.

The target alfentanil plasma concentration for induction in the first 10 patients was 475 ng/ml, to be achieved in 2 minutes. This choice was based on a previously reported plasma concentration-effect study with TIAC in young adults.[14] However, there was a high incidence of hypotension and muscle rigidity, and target plasma concentrations for induction were gradually decreased (down to 300 ng/ml) in the remaining eight patients (Table 2).

Suxamethonium 1 mg/kg was given when consciousness was lost, the trachea was intubated and the lungs were ventilated with 66% nitrous oxide in oxygen to an end-tidal carbon dioxide concentration between 4 and 5%. After tracheal intubation, the target alfentanil plasma concentration was lowered to 250 ng/ml, but was raised by 50–100 ng/ml if the patient exhibited signs of inadequate anaesthesia during surgery. If necessary, this was repeated every 5 minutes. Inadequate anaesthesia was defined as: an increase in systolic arterial pressure by more than 15 mmHg above normal for that patient (normal was defined as the lowest pressure measured in the time from admission to hospital until just before premedication); heart rate greater than 90 beats/minute in the absence of hypovolaemia; other autonomic signs such as sweating, flushing or lacrimation; somatic responses such as movement, swallowing, coughing, grimacing or eye movement.

The target alfentanil plasma concentration was lowered by 50 or 100 ng/ml if a patient did not respond during a 15-minute period. This interval was decreased to 5 minutes after the peritoneum was closed. Pancuronium was given at the minimal dose necessary for surgery in order to facilitate the identification of a somatic response. Neuromuscular blockade was monitored with the train-of-four method, by percutaneous stimulation of the facial nerve (Myotest: Odense, Denmark). Fluid balance was evaluated at least every 15 minutes, and maintained positive. Central venous pressure was maintained above 8 mmHg during intra-abdominal procedures. Intravenous fluids consisted of 0.9% NaCl and, when indicated, either colloids or whole blood.

Nitrous oxide was discontinued at the end of surgery and residual neuromuscular blockade was antagonised, if indicated, with neostigmine 1 mg given with atropine 0.5 mg. The trachea was extubated after recovery of consciousness and when adequate ventilation was established (frequency > 10 breaths/minute, end-tidal $CO_2 < 6.5\%$, tidal volume > 7 ml/kg). Naloxone 40 μg was given intravenously if ventilation was not adequate 10 minutes after discontinuation of nitrous oxide, and repeated every 3 minutes until adequate ventilation occurred without verbal encouragement. Naloxone 40 μg was given intravenously in the recovery room when ventilatory rate was less than 8 breaths/minute. The level of consciousness was evaluated 15, 30 and 60 minutes after extubation, by asking standard questions. These were: what day is it; do you know where

Table 2. Alfentanil plasma concentrations at intubation, dose of alfentanil in the first 2 minutes and observed side effects during induction of anaesthesia.

	Plasma concentration						
			Dose		Side effects*		
Patient no.	Predicted (ng/ml)	Measured** (ng/ml)	(mg)	(μg/kg)	Rigidity	Hypotension	Bradycardia
1	475	570	6.6	106	−	+	−
2	475	753	6.6	106	+	+ +	+ (40)
3	475	736	6.6	105	−	+	−
4	475	627	6.6	84	−	−	−
5	475	673	6.6	112	−	−	−
6	475	692	6.6	147	+	+	−
7	475	647	6.6	88	+	−	−
8	475	636	6.6	79	+	−	−
9	475	870	6.6	103	−	+	−
10	475	971	6.6	87	−	+ +	−
11	400	705	5.7	105	+ +	+ +	−
12	400	619	5.7	74	−	−	−
13	375	570	5.3	83	−	−	+ (38)
14	375	536	5.3	72	−	+ +	−
15	350	560	4.9	57	+ +	−	+ (20)
16	300	319	4.2	76	+	−	−
17	300	538	4.2	65	+	−	+ (42)
18	300	583	4.2	62	−	−	−

* Rigidity: +, rigid, ventilation possible by mask; + +, ventilation impossible by mask without suxamethonium. Hypotension: +, 15–30% decrease in systolic arterial pressure; + +, $> 30\%$ decrease in systolic arterial pressure. Bradycardia: +, heart rate < 50 beats/minute. Rate shown in parentheses. ** Measured concentration higher than predicted concentration (paired *t*-test, $p < 0.001$).

you are; how much is 4 times 7? The incidences of postoperative pain, nausea and vomiting during the 2-hour period in the recovery room were recorded.

Arterial blood samples were collected for the determination of alfentanil plasma concentrations before induction of anaesthesia, just before any change in the target alfentanil plasma concentration and 3, and 15 minutes thereafter. Additional blood samples were taken immediately after intubation, at the time of extubation and 15, 30 and 60 minutes after extubation. Plasma concentrations of alfentanil were determined by a capillary gas chromatographic method with a coefficient of variation that did not exceed 5% in the concentration range concerned.

The difference between the measured and predicted concentrations of alfentanil (prediction error) was calculated for each blood sample. Subsequently, as a measure of bias, the mean prediction error was determined for each patient by averaging the prediction errors of all blood samples obtained for that patient:

$$\text{Mean prediction error} = \frac{\Sigma\text{prediction error (ng/ml or \%)}}{\text{Number of samples per patient}}$$

In addition, the mean absolute prediction error was calculated. This is *not* influenced by the positive or negative sign of the prediction error and provides direct information on the typical magnitude of the error for each patient.[15]

Data are expressed as mean (SD) or as the incidence of observations, unless specified otherwise. The mean prediction errors were evaluated statistically by examining the corresponding 95% confidence intervals for each patient. The paired *t*-test and two sample *t*-tests were used for intragroup and intergroup comparisions respectively. A value of $p < 0.05$ was regarded as statistically significant.

Results

Details of the predicted and measured plasma alfentanil concentrations, alfentanil dose, and the incidences of side effects in individual patients during induction of anaesthesia, are shown in Table 2.

All patients lost consciousness within 1–2 minutes after the alfentanil infusion was started. The amount of alfentanil given in the first 2 minutes was 6.6 mg in the first 10 patients, and from 5.7 to 4.2 mg in the remaining eight. In one patient (patient 16, Tables 1 and 2), systolic arterial pressure increased by more than 15 mmHg during laryngoscopy and tracheal intubation. Systolic arterial pressure decreased more than 15% in eight patients. The decrease was greater than 30% in four of these patients (to 80 mmHg in two patients and to 60 mmHg in the other two). Arterial pressure in these four patients returned to normal after administration of ephedrine 7.5 mg intravenously and rapid infusion of 200–300 ml saline. In one patient, hypotension was associated with a bradycardia of 42 beats/minute, but heart rate and arterial pressure were restored rapidly to pre-induction values after administration of atropine 0.25 mg intravenously. Three other patients developed severe bradycardia (40, 38, 20 beats/minute) without hypotension, and were treated successfully with atropine 0.25 mg intravenously. Bradycardia did not recur during surgery. ST segment changes were not observed in the ECG in any patient. Eight patients developed muscle rigidity after loss of consciousness despite pretreatment with pancuronium. Ventilation was not possible in two of these until suxamethonium had been given.

The average dose of alfentanil given in the first 2 minutes to the patients who developed hypotension at induction of anaesthesia was 103 (21) μg/kg. The mean (SD) measured plasma concentration at intubation in these patients was 729 (143) ng/ml. Patients who did not develop hypotension received an average dose of 78 (15) μg/kg and the measured plasma concentration was 577 (100) ng/ml. These differences between patients who did or did not develop hypotension were statistically significant for both dose ($p = 0.009$) and plasma concentration ($p = 0.017$). There were no correlations between the incidences of bradycardia

Table 3. Predicted and measured plasma concentrations in individual patients and % of the duration of surgery during which systolic arterial pressure and heart rate were outside the indicated ranges.

Patient no.	Predicted plasma concentration (ng/ml range)	Measured plasma concentration (ng/ml range)	Systolic arterial pressure > 15 mmHg above normal (%)	Systolic arterial pressure > 15 mmHg below normal* (%)	Heart rate above 90 beats/minute (%)
1	900–250	935–231	9	—	15
2	365–120	495–223	3	14	—
3	350–188	592–212	—	8	—
4	500–300	518–254	11	—	6
5	400–250	378–226	—	—	—
6	400–180	535–236	2	26	1
7	550–250	528–206	13	—	3
8	400–250	419–210	4	—	—
9	250–100	231–72	—	49	—
10	550–175	637–186	10	5	—
11	275–175	354–228	6	42	6
12	400–193	478–139	14	—	—
13	350–250	502–297	22	27	—
14	275–159	379–209	11	23	—
15	200–105	265–139	2	18	—
16	400–200	911–406	9	12	—
17	250–125	498–230	8	24	—
18	275–150	267–87	7	14	—

* No decreases > 30 mmHg below normal.

Table 4. Number of responses (*n*) during surgery (18 patients).

	n	Range per patient
Systolic arterial pressure > 15 mmHg above normal	55	0–7
Heart rate above 90 beats/minute	11	0–4
Somatic response	21	0–4
Other responses	5	0–2

or muscle rigidity and either dose or measured plasma concentration of alfentanil.

During surgery, systolic arterial pressure never decreased more than 30 mmHg below normal. Systolic arterial pressure and heart rate remained within the normal range for most of the duration of surgery (Table 3). A response to the fourth stimulus of the train-of-four was detectable during 62 (24)% of the anaesthesia time. The incidences of haemodynamic, somatic and other responses during surgery are shown in Table 4. All responses were controlled rapidly by increasing the target plasma concentration. Systolic arterial pressure returned to normal within 12 minutes (median 2 minutes); heart rate returned to normal within 8 minutes (median 2 minutes). The measured and predicted plasma concentrations obtained in the individual patients during surgery are summarised in Table 3.

The average duration of anaesthesia was 162 (42) minutes. The total dose of alfentanil given was 23.5 (10.7) mg. The trachea was extubated 35 (8) minutes after the end of the alfentanil infusion (11 (7) minutes after administration of nitrous oxide had stopped). Nine patients required naloxone intravenously (average dose 80 (30) μg) to restore adequate spontaneous ventilation. The measured alfentanil plasma concentration in these patients at the time of extubation was 238 (132) ng/ml. The corresponding concentration in the patients who did not require naloxone was 199 (76) ng/ml. This difference was not statistically significant. Three patients developed respiration frequencies of less than 8 breaths/minute after extubation. All had received naloxone before extubation. The first patient was given additional naloxone at 10 and 13 minutes after extubation, the second patient 12 and 30 minutes after extubation and the third 16 and 60 minutes after extubation.

The plasma concentration of alfentanil decreased in all patients after the infusion was stopped, and no secondary increases occurred. The average $Pa\text{CO}_2$ values determined 15, 30 and 60 minutes after extubation were 5.9 (1.3), 5.8 (1.2) and 5.6 (1.2) kPa, respectively. The percentages of correct answers to standard questions at these times were 65%, 80% and 98%, respectively. Eight patients complained of nausea and five of these vomited. Four patients needed additional analgesia within 2 hours of surgery. No patient had any recall of the anaesthesia or surgical period when questioned on the day after surgery.

Figure 1 shows the relationship between the measured and predicted concentrations of alfentanil for all samples collected during anaesthesia, that is from induction until extubation. Comparison of the data points with the line of identity indicates a general underprediction of the plasma alfentanil concentration in the higher concentration range, as indicated by the greater number of data points beneath the line of identity. The measured alfentanil concentration at induction was higher than the predicted concentration in every patient (Table 2). The measured concentration exceeded the predicted concentrations in most patients during surgery (Table 3). The predicted (177 (62) ng/ml) and measured (219 (106) ng/ml) plasma alfentanil concentrations did not differ significantly at extubation. During anaesthesia both the mean prediction error and the

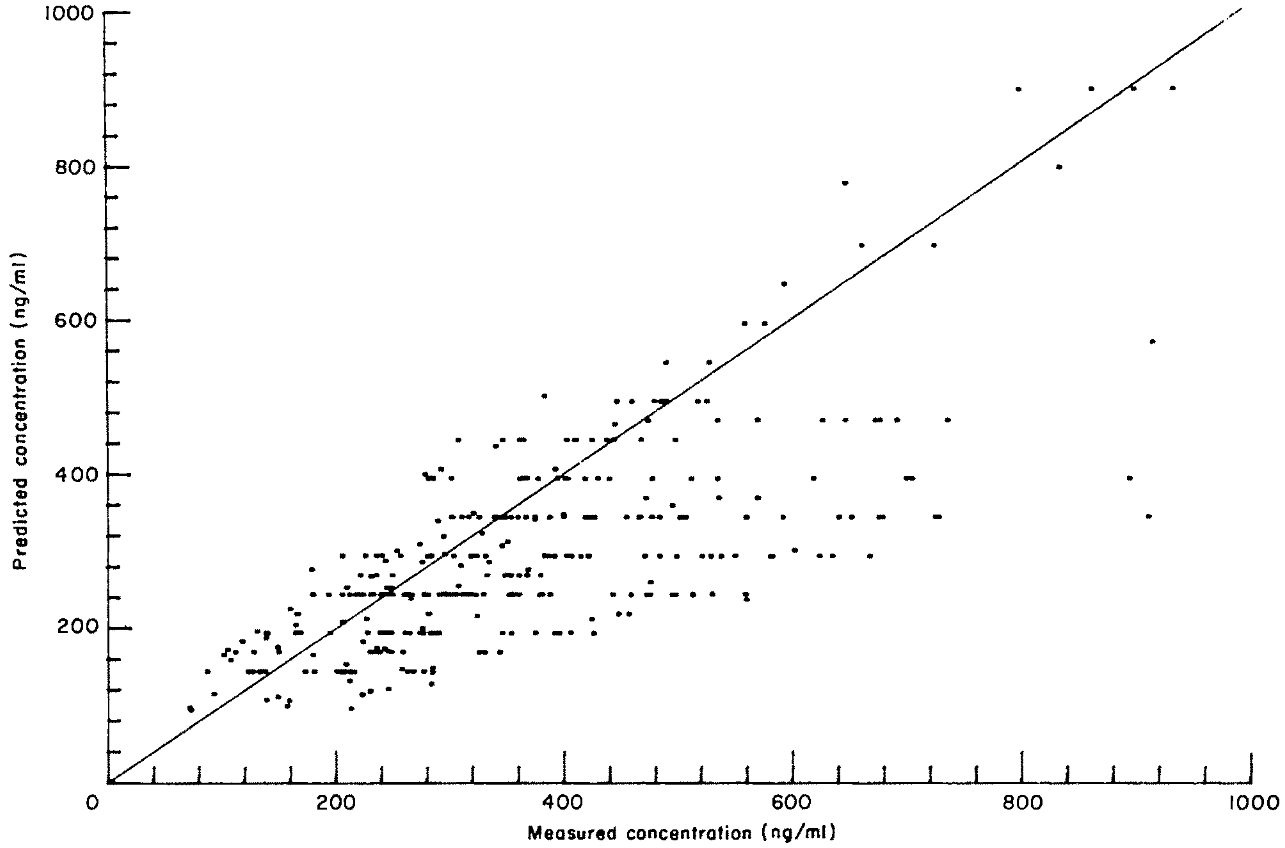

Fig. 1. Plot of the predicted alfentanil concentration compared to measured plasma alfentanil concentration, and the line of identity (n = 346).

Table 5. Mean and mean absolute prediction errors of alfentanil concentrations during anaesthesia.

Patient		Mean predicted error				Mean absolute prediction error			
no.	*n*	ng/ml	(SD)	%	(SD)	ng/ml	(SD)	%	(SD)
1	29	−20	(42)	−4.2	(7.5)	37	(28)	7.2	(4.5)
2	13	165	(95)	42.2	(6.8)	165	(95)	42.2	(6.8)
3	17	107	(88)	23.4	(15.9)	112	(82)	25.3	(12.4)
4	20	14	(56)	1.3	(12.8)	36	(44)	8.8	(9.3)
5	14	−9	(65) NS	−7.5	(16.6) NS	43	(48)	13.3	(12.0)
6	22	92	(45)	23.8	(7.8)	92	(45)	23.8	(7.8)
7	23	−34	(83) NS	−14.9	(26.2)	80	(39)	25.5	(15.4)
8	19	−19	(43) NS	−7.7	(12.9)	33	(33)	12.0	(9.6)
9	12	−10	(27) NS	−11.6	(16.8)	25	(12)	16.7	(11.0)
10	18	73	(31)	11.7	(9.2)	73	(31)	11.7	(9.2)
11	15	82	(63)	24.7	(8.0)	82	(63)	24.7	(8.0)
12	19	22	(82) NS	−1.6	(25.4) NS	70	(46)	22.5	(10.7)
13	20	88	(37)	22.6	(6.3)	88	(37)	22.6	(6.3)
14	20	63	(44)	19.7	(11.4)	65	(41)	20.3	(10.1)
15	15	60	(43)	24.5	(6.6)	60	(43)	24.5	(6.6)
16	27	286	(69)	49.0	(4.3)	286	(69)	49.0	(4.3)
17	18	176	(54)	46.7	(5.8)	176	(54)	46.7	(5.8)
18	25	−40	(26)	−30.0	(23.6)	43	(21)	31.0	(22.3)
Whole group									
Mean (SD)	19 (5)	61	(86)	11.8	(22.5)	87	(65)	23.8	(12.1)

n, number of blood samples for each patient. NS, no significant bias since the 95% confidence bound of the bias includes zero.

mean absolute prediction error varied widely between individual patients (Table 5). A significant overprediction occurred in two patients, whereas a significant underprediction occurred in 11. The average mean prediction error was 61 ng/ml (11.8%). The average absolute mean prediction error was 87 ng/ml (23.8%).

Discussion

A computer-controlled infusion has the advantage over intermittent bolus injections in that large and unnecessary overshoots in the plasma concentrations are avoided and the total dose is lower.[5–7] In comparison with manually adjusted infusions, computer-controlled infusions have the advantage that stabler plasma concentrations can be rapidly achieved and maintained, and adjusted to a higher or lower level. An increase in the plasma concentration may be obtained almost instantaneously without a marked overshoot. In contrast, a manual adjustment to obtain higher plasma concentrations results either in a significant delay if the infusion rate alone is altered, or a significant overshoot if a bolus injection is given. The computer will stop the infusion when a lower plasma concentration is required until the plasma concentration decreases to that concentration, after which the infusion rate is adjusted automatically to maintain that concentration.

The haemodynamic responses during induction of anaesthesia with alfentanil in our elderly patients were different from those reported in young patients.[3,16] Induction was accompanied by a high incidence of hypotension which was dose- and plasma-concentration dependent. There were also high incidences of bradycardia and muscle rigidity, which were dose- and plasma-concentration independent. Young adults given alfentanil 100–250 μg/kg for induction of anaesthesia do not develop profound hypotension,[16] although there is a significant increase in heart rate after administration of alfentanil, but before any stimulation. This tachycardia may be a compensatory response to the haemodynamic changes caused by alfentanil. In contrast, increases in heart rate did not occur in our elderly patients. This absence of a compensatory tachycardia may partly explain the hypotension in our patients. The use of nitrous oxide in our patients may also have contributed to the incidence of hypotension. Nitrous oxide was not used in the study by McDonnel *et al.*[16] The combination of high doses of fentanyl and nitrous oxide can result in significant cardiovascular depression.[17]

The correlation between the development of hypotension and both dose and plasma concentration of alfentanil emphasises the need for caution in the acute administration of this drug to elderly patients. Our results indicate that hypotension is less likely to occur when the plasma alfentanil concentration is kept below 500–550 ng/ml. This can be achieved by reducing the dose and the speed of injection. We would recommend that in the elderly, in contrast to young adults, bolus injection of alfentanil in an unstimulated patient should not exceed 50–70 μg/kg given over 3–5 minutes.

Severe bradycardia occurred in four of 18 patients in our study, although this was associated with hypotension in only one patient. Bradycardia is a known pharmacological effect of opioids, and is minimised by premedication with atropine or by slow administration.[18] In our study, atropine 0.25 mg was given intramuscularly as premedication and the induction dose of alfentanil was given over 2 minutes. In view of our findings we recommend that, particularly in elderly patients, atropine should be given intravenously before administration of alfentanil for induction of anaesthesia.

Systolic arterial pressure and heart rate during surgery were maintained within preset values for most of the anaesthesia time. Cardiovascular and other responses to surgical stimulation were controlled rapidly by increasing the plasma alfentanil concentration. The occurrence of responses to surgical stimulation is an inherent part of any technique in which the anaesthetic dose rate is titrated to the patient's requirements.

Postoperative recovery in our elderly patients was not as rapid as we had hoped for. Naloxone was needed to restore adequate ventilation in half of the patients despite careful titration of the plasma concentrations. This is in contrast to the rapid postoperative recovery of spontaneous ventilation in young healthy adult patients after variable rate infusion of alfentanil.[9] The recurrence of ventilatory depression in three patients after the initial dose of naloxone was not associated with secondary increases of the alfentanil plasma concentration. Such increases have been suggested as a cause of delayed ventilatory depression in patients who have received intra-operative fentanyl.[19] The recurrence of ventilatory depression in our patients may be related to the small doses of naloxone given, and its short duration of action.

We found considerable differences between the measured and predicted concentrations despite the use of pharmacokinetic data obtained from elderly patients who were comparable to the population in our study. The largest differences occurred with the highest predicted plasma concentrations, which were reached after rapid increases, for instance during induction of anaesthesia or in response to intense surgical stimulation. The measured concentrations in these situations generally exceeded the predicted concentrations. This suggests that the initial volume of distribution in the pharmacokinetic model used by the computer overestimated the actual volume of distribution in our patients.

In conclusion, we have demonstrated that computer-controlled infusion of alfentanil as a supplement to nitrous oxide anaesthesia is a useful technique in elderly patients who undergo general surgery. It is, however, associated with a high incidence of dose (plasma concentration)-dependent hypotension, and dose-independent bradycardia and muscle rigidity during induction of anaesthesia. There was a high incidence of ventilatory depression at the end of surgery. The discrepancy between the measured and predicted alfentanil plasma concentrations during prolonged computer-assisted alfentanil infusion indicates the necessity for better characterisation of the pharmacokinetics of alfentanil in elderly patients. This would prevent significant underprediction during induction of anaesthesia and reduce the incidence of hypotension.

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References

1. Scott JC, Ponganis KV, Stanski DR. EEG quantitation of narcotic effect: the comparative pharmacodynamics of fentanyl and alfentanil. *Anesthesiology* 1985; **62:** 234–41.
2. Bovill JG, Sebel PS, Blackburn CL, Heykants J. The pharmacokinetics of alfentanil (R39209): a new opioid analgesic. *Anesthesiology* 1982; **57:** 439–43.
3. Nauta JH, De Lange S, Koopman DW, Spierdijk J, Van Kleef JW, Stanley TH. Anesthetic induction with alfentanil: a new short-acting narcotic analgesic. *Anesthesia and Analgesia* 1982; **61:** 267–72.
4. Stanski DR, Hug CC. Alfentanil—a kinetically predictable narcotic analgesic. *Anesthesiology* 1982; **57:** 435–8.

5. White PF. Use of continuous infusion versus intermittent bolus administration of fentanyl or ketamine during outpatient anesthesia. *Anesthesiology* 1983; **59:** 294–300.
6. De Lange S, De Bruijn NP. Alfentanil–oxygen anaesthesia: plasma concentrations and clinical effects during variable-rate continuous infusion for coronary artery surgery. *British Journal of Anaesthesia* 1983; **55:** 183S–9S.
7. Ausems ME. Intravenous infusion of alfentanil as a supplement to nitrous oxide anesthesia, PhD Thesis, University of Leiden, The Netherlands 1986: 61–75.
8. Helmers JH, Van Peer A. Woestenborghs R, Noorduin H, Heykants J. Alfentanil kinetics in the elderly. *Clinical Pharmacology and Therapeutics* 1984; **36:** 239–43.
9. Ausems ME, Hug CC, De Lange S. Variable rate infusion of alfentanil as a supplement to nitrous oxide anesthesia for general surgery. *Anesthesia and Analgesia* 1983; **62:** 982–6.
10. Van Leeuwen L, Zuurmond WWA, Helmers JH, Noorduin H, Deen L. Alfentanil—Dauerinfusion für chirurgische Eingriffe mittlerer und längerer Dauer. English title: Continuous alfentanil infusion in surgical interventions of intermediate and long duration. *Anaesthesist* 1984; **33:** 173–6.
11. Alvis JM, Reves JG, Govier AV, Menkhaus PG, Henling CE, Spain JA, Bradley E. Computer-assisted continuous infusions of fentanyl during cardiac anesthesia: comparison with a manual method. *Anesthesiology* 1985; **63:** 41–9.
12. Ausems ME, Stanski DR, Hug CC. An evaluation of the accuracy of pharmacokinetic data for the computer assisted infusion of alfentanil. *British Journal of Anaesthesia* 1985; **57:** 1217–25.
13. Schwilden H. A general method for calculating the dosage scheme in linear pharmacokinetics. *European Journal of Clinical Pharmacology* 1981; **20:** 379–86.
14. Ausems ME, Hug CC, Stanski DR, Burm AGL. Plasma concentrations of alfentanil required to supplement nitrous oxide anesthesia for general surgery. *Anesthesiology* 1986; **65:** 362–73.
15. Sheiner LB, Beal SL. Some suggestions for measuring predictive performance. *Journal of Pharmacokinetics and Biopharmaceutics* 1981; **9:** 503–12.
16. McDonnell TE, Bartkowski RR, Williams JJ. ED_{50} of alfentanil for induction of anesthesia in unpremedicated young adults. *Anesthesiology* 1984; **60:** 136–40.
17. Lunn JK, Stanley TH, Eisele J, Webster L, Woodward A. High dose fentanyl anesthesia for coronary artery surgery: plasma fentanyl concentrations and influence of nitrous oxide on cardiovascular responses. *Anesthesia and Analgesia* 1979; **58:** 390–5.
18. Bovill JG, Sebel PS, Stanley TH. Opioid analgesics in anesthesia: with special reference to their use in cardiovascular anesthesia. *Anesthesiology* 1984; **61:** 731–55.
19. Stoeckel H, Schüttler J, Magnussen H, Hengstmann JH. Plasma fentanyl concentrations and the occurrence of respiratory depression in volunteers. *British Journal of Anaesthesia* 1982; **54:** 1087–95.

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The effect of tracheal intubation and surgical stimulation on median nerve somatosensory evoked potentials during anaesthesia

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Summary

This study was designed to determine whether alterations in the median nerve somatosensory evoked potentials occur during the stimuli of tracheal intubation and skin incision. Twenty-two patients scheduled for elective surgery and who required tracheal intubation were studied. Median nerve somatosensory evoked potentials were recorded, analysed and stored approximately every 40 seconds. Anaesthesia was induced with thiopentone and vecuronium used for neuromuscular blockade; the trachea was intubated 2 minutes after induction. Fentanyl 1.5 μg/kg was administered subsequently. Evoked potential monitoring was continued until at least 2 minutes after surgical incision. Induction of anaesthesia was associated with an increase in evoked potential latency of 0.8 msec and reduction in amplitude of 1.7 μV. Small, statistically insignificant changes occurred between induction of anaesthesia and tracheal intubation. Surgical incision was accompanied by a statistically significant mean decrease in evoked potential latency of 0.5 msec and a statistically significant increase in evoked potential amplitude of 0.6 μV. The fact that surgical stimulation produced an activating effect on evoked potentials suggests that they may be used as a measure of the neurophysiological effects of anaesthesia.

Key words

Brain; evoked potentials.
Anaesthesia; depth.

Conventionally, anaesthetists monitor signs of autonomic activity to assess depth of anaesthesia.[1] Measures that are not directly related to cerebral function, such as lower oesophageal contractility[2] and frontalis electromyogram,[3] have also been proposed. Attempts to use the unprocessed electroencephalogram (EEG) have been disappointing;[4] various methods of computerised analysis[5–7] have been described but they have not been universally acceptable.[8]

A satisfactory method of measuring anaesthetic depth is required. There exists much concern about awareness.[1] It has been suggested that sensory evoked potentials may provide a useful index to anaesthetic depth.[9] Anaesthesia prolongs the latency and decreases the amplitude of cortical evoked potentials, but it is not known whether auditory cortical potentials[10] or median nerve somatosensory cortical potentials[11] will provide the more useful index of anaesthetic effects on the central nervous system. Evoked responses can be established as a measure of anaesthetic depth, only if, during light anaesthesia, surgical stimulation produces an activating effect on evoked potentials and reverses the effects of anaesthesia to some extent. The purpose of the present study was to determine whether alterations in median nerve somatosensory evoked potentials occur during the stimuli of tracheal intubation and skin incision.

Method

Twenty-two patients of mean (SD) age 54.5 (17.1) years and weight 73.0 (13.2) kg scheduled to undergo elective surgery that required tracheal intubation were studied after Local Ethics Committee approval and informed consent. All patients were premedicated with papaveretum 10–20 mg and hyoscine 0.2–0.4 mg intramuscularly one hour before the scheduled time of operation. Median nerve somatosensory evoked potentials (SEP) were recorded on arrival in the operating theatre using a Cadwell 7400 which was controlled by a Compaq portable computer running Sentry software (Cadwell Laboratories, Kennewick WA, USA). This software allows for the automatic acquisition, analysis and storage of evoked potentials. These are acquired every 30 seconds, and passed to the Compaq for automatic display, analysis and storage on disk. The low cut filter on the Cadwell 7400 was set at 10 Hz, the high

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Table 1. Evoked response latencies and amplitudes for 22 patients. Data are expressed as mean (SD).

	Baseline	After induction	After intubation	Before incision	After incision
Latency, msec	21.1 (1.8)	21.9 (1.8)	21.6 (1.8)	21.5 (1.7)	21.0 (1.7)
Amplitude, μV	4.6 (2.5)	2.9 (1.5)	3.3 (1.8)	1.7 (1.0)	2.3 (1.1)

	Latency		Amplitude	
	t	p	t	p
After induction vs baseline	5.23	0.001	4.3	0.0003
After intubation vs after induction	1.11	0.27	1.5	0.14
Before incision vs after intubation	0.34	0.73	4.5	0.0002
After incision vs before incision	3.5	0.002	3.03	0.006

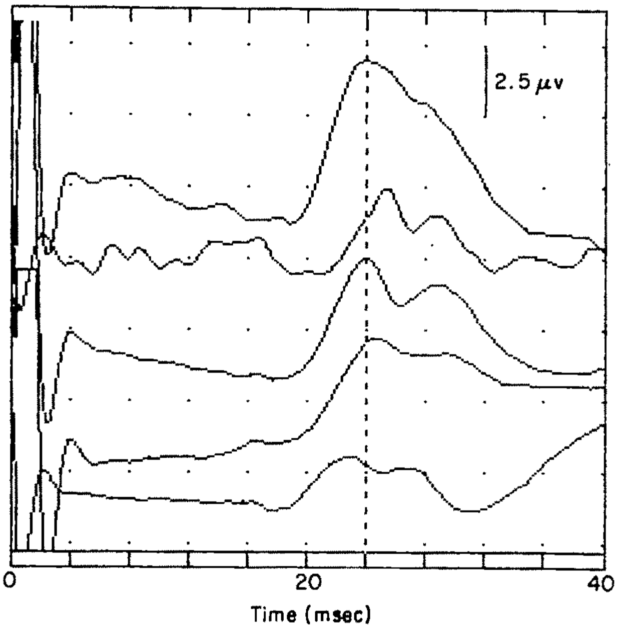

Fig. 1. Median nerve somatosensory evoked potentials from one patient. Time in msec is shown on the axis and the stimulus was given at time zero. Each response represents the average of 232 repetitions. An upward deflection indicates a negative potential. The top potential was measured before induction of anaesthesia and shows the latency of 24.0 msec and an amplitude of 6.3 μV. The second potential was measured 45 seconds after induction of anaesthesia and shows a latency of 25.3 msec and an amplitude of 3.0 μV. The third potential was measured after tracheal intubation and shows a decrease in latency to 24 msec and an increase in amplitude to 4.14 μV. The fourth potential was measured just before skin incision and shows a latency of 24.7 msec and amplitude of 1.7 μV. The fifth, bottom, tracing was measured just after skin incision and shows a decrease in latency to 23.0 msec and an increase in amplitude to 2.03 μV.

cut filter at 1000 Hz and each epoch was 50 msec. Adhesive electrodes (Meditronic TENS electrodes) were placed over the median nerve which was stimulated with a constant current pulse generator set at 150% of motor threshold (i.e. supramaximal for sensory stimulation) at a rate of 10 Hz for 232 repetitions. The SEPs were recorded using silver-silver chloride electrodes in the following derivations, based on the international 10–20 system:[12]

$C5—F_{pz}$ (5th cervical vertebra—frontal)

$C_3'—F_{pz}$ (C_3' is a rolandic placement over the sensory cortex midway between C_3 and P_3).

Electrode resistances were less than 2 kΩ in all cases. A baseline potential was recorded on the Cadwell 7400 and passed to the Compaq, where the first major negative peak of the cortical evoked potential was identified for tracking. Continuous recordings of median nerve SEPs were obtained from before the start of induction of anaesthesia until at least 2 minutes after skin incision.

Induction of anaesthesia was with a 'sleep' dose of thiopentone. Vecuronium 0.1 mg/kg was used to provide neuromuscular blockade. The lungs were ventilated with nitrous oxide and oxygen ($F\mathrm{IO}_2 = 0.5$). The trachea was intubated 2 minutes after induction of anaesthesia. Fentanyl 1.5 μg/kg was administered at least 3 minutes after tracheal intubation. Surgical incision was made in the next few minutes.

Measures of latency and amplitude of the evoked potentials were reviewed offline. The latency was measured from the time of stimulus until the appearance of the first major negative peak (measured at maximum deflection). The amplitude of that evoked potential was measured from the negative peak to the succeeding positive trough. Statistical analysis was with Student's paired *t*-test and was performed on the data obtained 45 seconds after loss of eyelash reflex (postinduction), 45 seconds after tracheal intubation (postintubation), just before skin incision (pre-incision), and 45 seconds after skin incision (postincision).

Results

Typical responses from one patient are shown in Fig. 1. Induction of anaesthesia was accompanied by an increase in the latency of the evoked potential and a reduction in amplitude. Tracheal intubation was accompanied by a decrease in evoked potential latency to that of the pre-induction value and an increase in amplitude, though not back to pre-induction levels. Evoked potential latency was not altered but the amplitude decreased in the period before skin incision, when the patient had not been stimulated for a period of time. There was a reduction in evoked potential latency following skin incision to less than that of the pre-induction value, and this was accompanied by an increase in amplitude from the pre-incision value.

The results for all 22 patients are shown in Table 1. The mean increase in evoked potential latency associated with induction of anaesthesia was 0.8 msec and the reduction in amplitude was 1.7 μV. However, not all patients showed this trend. The increase in latency on induction of anaesthesia in two subjects was less than 0.4 msec, there was no apparent increase in evoked potential latency in one subject, and there was a decrease in evoked potential latency of 0.5 msec in one subject. Not all patients showed the same trend with respect to amplitude; three subjects showed an increase in amplitude of more than 0.4 μV on induction of anaesthesia.

Overall, the changes that occurred between induction of anaesthesia and tracheal intubation were small and did not reach statistical significance. There was no statistically significant change in evoked potential latency between pre-incision and postintubation recordings. However, there was a statistically significant decrease in amplitude (mean 1.6 μV).

Surgical incision was accompanied by a statistically significant mean decrease in evoked potential latency of 0.5 msec and a statistically significant increase in evoked potential amplitude of 0.6 μV. This reduction in evoked potential latency compared with the pre-incision period was shown by all but two patients: no change occurred on skin incision in one, and there was an increase in evoked potential latency of 0.9 msec in the other. The changes in amplitude were more variable; nine patients did not show an increase in amplitude on skin incision.

Discussion

Somatosensory evoked potentials are monitored routinely during anaesthesia and surgery in order to test the integrity of specific neural pathways.[13] Surgical interruption of the pathways leads to loss of signal, and evoked potential monitoring may be useful in predicting neurological outcome, particularly after scoliosis surgery.[13] Research into the effects of differing anaesthetic techniques on SEPs has concentrated on determining which anaesthetic techniques can be used and yet retain satisfactory recordings of cortical evoked potentials. Halothane, enflurane and isoflurane have been found to produce dose-related reductions in amplitude and increases in latency of cortical components of the median nerve SEP.[14,15] Thiopentone (4 mg/kg) and large doses of fentanyl (25 μg/kg) were found to produce a moderate increase in latency and reduction in amplitude of the cortical components of median nerve SEP.[16]

Factors other than anaesthetic agents may also affect evoked potential measurements during surgery. A reduction in body temperature prolongs the cortical latency of median nerve SEP by 1 msec/degree C change in temperature.[17] It is well known that alterations in carbon dioxide tension produce alterations in the EEG, and it is probable that they affect evoked potentials also, although this has not been investigated systematically.

The fact that the volatile anaesthetic agents isoflurane,[15] halothane and enflurane,[18] the intravenous anaesthetics etomidate[19] and Althesin,[20] and nitrous oxide[21] all produce similar dose-related alterations in cortical evoked potentials has led to the suggestion that these potentials may be used as a neurophysiological index of depth of anaesthesia.[9,10] All anaesthetics produce an increase in evoked potential latency and a reduction in amplitude, and it is reasonable to assume that the effects of general anaesthesia can be measured in the central nervous system by measuring cortical evoked potentials. It is not yet clear whether this is the same as depth of anaesthesia. The early cortical components of the auditory response are suppressed completely by intravenous and volatile anaesthetics at a dose equivalent to the minimum alveolar concentration (MAC) of anaesthetic required to suppress the response to surgical stimulus in half the patients studied.[10] Surgical stimulation causes an increase in evoked potential amplitude in the presence of light anaesthesia.[11] Attempts to correlate evoked potential measures with conventional cardiovascular measures have been unsatisfactory,[11] but evoked potentials were recorded over approximately 80 seconds and cardiovascular measurements were made discretely, and it is therefore not surprising that no satisfactory relationship could be established. In fact, cardiovascular responses may occur independently of neurophysiological responses; the two were found to occur at different times[22] in a study of somatic responses to light anaesthesia.

We have demonstrated in this study that surgical stimulation, the stimulation of skin incision, produces an activating effect on evoked potentials, with a statistically significant decrease in latency and a statistically significant increase in amplitude. The latency changes were more consistent in our study group, and were shown by all but two patients; only 13 out of our 22 subjects showed an increase in evoked potential amplitude on skin incision. Induction of anaesthesia was accompanied by the expected increase in latency and decrease in amplitude. We observed no measurable responses to placement of the tracheal tube. This is possibly because the patients were relatively deeply anaesthetised with thiopentone at that time, but the blood and brain concentrations would have fallen much more by the time of skin incision. Induction of anaesthesia was associated with a decrease in evoked potential latency of 0.5 msec in one patient and an increase in amplitude in three subjects. Light levels of thiopentone anaesthesia are known to produce an increase in high frequency fast wave activity in the EEG.[4] It may be that this was reflected by a decrease in evoked potential latency or an increase in amplitude. The postincision latency measure for the entire study group was approximately the same as the baseline value. The postincision latency was shorter than baseline on some occasions (for example in Fig. 1). The implications of this finding are uncertain. It may be that an evoked potential latency decrease to less than that of baseline may be indicative of impending arousal leading to awareness. However, none of the patients in this study reported any incident of awareness.

The Sentry system allowed us to acquire evoked potential data faster than had been possible previously. None of the patients had an indwelling arterial catheter, and no attempts were made to correlate cardiovascular changes with alterations in evoked potentials. We have, however, demonstrated that during balanced nitrous oxide and fentanyl anaesthesia, surgical stimulation produces an activating effect upon cortical SEPs. This suggests that SEPs may be useful as a neurophysiological index of depth of anaesthesia. It is now necessary to demonstrate that the SEP response to skin incision does not occur with an adequate level of anaesthesia, that is, that the changes observed in this study do not occur during anaesthesia with high concentrations of volatile anaesthetic agents, in order to confirm that SEPs do indeed measure depth of anaesthesia.

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References

1. Editorial. The depth of anaesthesia. *Lancet* 1986; **ii:** 553–4.
2. Evans JM, Davies WL, Wise CC. Lower oesophageal contractility: a new monitor of anaesthesia. *Lancet* 1984; **i:** 1151–4.
3. Sebel PS. Evaluation of anaesthetic depth. *British Journal of Hospital Medicine* 1987; **38:** 116–7.
4. Clark DL, Rosner BS. Neurophysiologic effects of general anesthetics. I. The electroencephalogram and sensory evoked response in man. *Anesthesiology* 1973; **38:** 564–82.
5. Sebel PS, Maynard DE, Major E, Frank M. The cerebral function analysing monitor (CFAM). A new microprocessor-based device for the on-line analysis of the EEG and evoked potentials. *British Journal of Anaesthesia* 1983; **55:** 1265–70.
6. Rampil IJ, Susse FJ, Smith NT, Hoff BH, Flemming DC. Spectral edge frequency— a new correlate of anesthetic depth. *Anesthesiology* 1980; **53:** S12.
7. Scott JC, Ponganis KV, Stanski DR. EEG quantitation of narcotic effect: the comparative pharmacodynamics of fentanyl and alfentanil. *Anesthesiology* 1985; **62:** 234–41.
8. Withington PS, Morton J, Arnold R, Sebel PS, Moberg R. Assessment of power spectral edge for monitoring depth of anaesthesia using low methohexitone infusion. *International Journal of Clinical Monitoring and Computing* 1986; **3:** 117–22.
9. Sebel PS, Heneghan CP, Ingram DA. Evoked responses—a neurophysiological indicator of depth of anaesthesia? *British Journal of Anaesthesia* 1985; **57:** 841–2.
10. Jones JG, Konieczko K. Hearing and memory in anaesthetised patients. *British Medical Journal* 1986; **292:** 1291–3.
11. Sebel PS, Glass P, Neville WK. Do evoked potentials measure depth of anesthesia? *Anesthesiology* 1986; **65:** A542.
12. Jasper HH. The ten twenty electrode system of the International Federation. *Electroencephalography and Clinical Neurophysiology* 1958; **10:** 371–5.
13. Grundy BL. Intraoperative monitoring of sensory-evoked potentials. *Anesthesiology* 1983; **58:** 72–87.
14. Peterson DO, Drummond JC, Todd MM. Effects of halothane, enflurane, isoflurane, and nitrous oxide on somatosensory evoked potentials in humans. *Anesthesiology* 1986; **65:** 35–40.
15. Sebel PS, Ingram DA, Flynn PJ, Rutherfoord CF, Rogers H. Evoked potentials during isoflurane anaesthesia. *British Journal of Anaesthesia* 1986; **58:** 580–5.
16. McPherson RW, Sell B, Traystman RJ. Effects of thiopental, fentanyl, and etomidate on upper extremity somatosensory evoked potentials in humans. *Anesthesiology* 1986; **65:** 584–89.
17. Sebel PS, De Bruijn N, Neville WK. Effects of hypothermia on median nerve somatosensory evoked potentials. *Journal of Cardiothoracic Anesthesia* 1988; **2:** 326–9.
18. Thornton C, Heneghan CPH, James MFM, Jones JG. Effects of halothane or enflurane with controlled ventilation on auditory evoked potentials. *British Journal of Anaesthesia* 1984; **56:** 315–23.
19. Thornton C, Heneghan CPH, Navaratnarajah M, Jones JG. Selective effect of Althesin on the auditory evoked response in man. *British Journal of Anaesthesia* 1986; **58:** 422–7.
20. Thornton C, Heneghan CPH, Navaratnarajah M, Bateman PE, Jones JG. Effect of etomidate on the auditory evoked response in man. *British Journal of Anaesthesia* 1985; **57:** 554–61.
21. Sebel PS, Flynn PJ, Ingram DA. Effect of nitrous oxide on visual auditory and somatosensory evoked potentials. *British Journal of Anaesthesia* 1984; **56:** 1403–7.
22. Ausems ME, Hug CC. Plasma concentrations of alfentanil required to supplement nitrous oxide anaesthesia for lower abdominal surgery. *British Journal of Anaesthesia* 191S–7S.

Anaesthesia, 1988, Volume 43, pages 861–863

CASE REPORT

Coronary vasospasm during percutaneous trigeminal rhizotomy

B. SWERDLOW, L. SHUER AND J. ZELCER

Summary

A case of myocardial infarction as a result of coronary vasospasm during percutaneous trigeminal rhizotomy is presented. Potential consequences of the profound sympathetic response during this procedure are discussed. Invasive haemodynamic monitoring as well as prophylaxis with nitrates and calcium antagonists may be useful in patients prone to coronary vasospasm who undergo this procedure.

Key words

Complications; myocardial infarction.
Anaesthetic techniques; regional, trigeminal.

Percutaneous rhizotomy is often performed instead of major intracranial operative procedures in the management of trigeminal neuralgia.[1] Both radiofrequency electrocoagulation and glycerol rhizotomy are used frequently for this purpose, although profound hypertension is a well-documented occurrence during radiofrequency electrocoagulation,[2] and also occurs regularly during glycerol injection. This takes place despite local anaesthesia supplemented by intravenous barbiturates or neuroleptanalgesia. The aetiology of this sympathetic response is not well understood. The following case report describes an episode of myocardial ischaemia and infarction during glycerol injection of the trigeminal ganglion in a patient with anatomically normal coronary arteries.

Case history

A 63-year-old woman presented for glycerol rhizotomy of the right trigeminal ganglion. She had a 10-year history of left tic douloureux and had undergone two radiofrequency rhizotomies of the left trigeminal ganglion with significant improvement in her pain. However, she developed symptoms consistent with right-sided trigeminal neuralgia during the several months before admission.

Both of the patient's previous rhizotomies were performed with local anaesthesia supplemented by light sedation with intravenous methohexitone. These anaesthetics were associated with significant hypertension and one episode of sinus bradycardia responsive to atropine. The patient's pre-operative history was otherwise unremarkable. There was no record of angina pectoris, dyspnoea on exertion, hypertension, cigarette smoking, hypercholesterolaemia or family history of heart disease. Her only medication consisted of oral conjugated oestrogens (Premarin) 0.625 mg daily. The patient's blood pressure was 130/80 mmHg and pulse rate 88/minute on the day of surgery. Physical examination was normal except for moderate hyperaesthesia in the distribution of the second and third branches of the left trigeminal nerve. Pre-operative laboratory data which included a 12-lead electrocardiogram (ECG) were normal.

The patient was premedicated one hour before surgery with diazepam 10 mg orally. Standard monitoring devices were applied to the patient, upon arrival in the operating room, which included an ECG (using a CM5 lead configuration), automatic blood pressure cuff (Critikon Dinamap) and percutaneous oxygen saturation monitor (Nellcor Model N–100). Initial vital signs included a heart rate of 80/minute and blood pressure of 150/80 mmHg with a mean arterial pressure (MAP) of 105 mmHg. Methohexitone 1 mg/kg was administered intravenously after 1% lignocaine had been infiltrated over the operative site. An 18-gauge spinal needle was then inserted through the right cheek into the foramen ovale. Free-flowing cerebrospinal fluid was obtained and correct position of the needle was confirmed by fluoroscopy. The patient was allowed to awaken and placed in a semi-sitting position.

Undiluted anhydrous glycerol (0.6 ml) was then instilled into the retrogasserian cistern of Meckel's cave. The patient's blood pressure immediately increased to 190/120 (MAP of 140 mmHg) and her heart rate to 98/minute. Multifocal ventricular premature beats appeared and were followed by a short self-terminating run of ventricular tachycardia. A bolus of lignocaine 100 mg was administered

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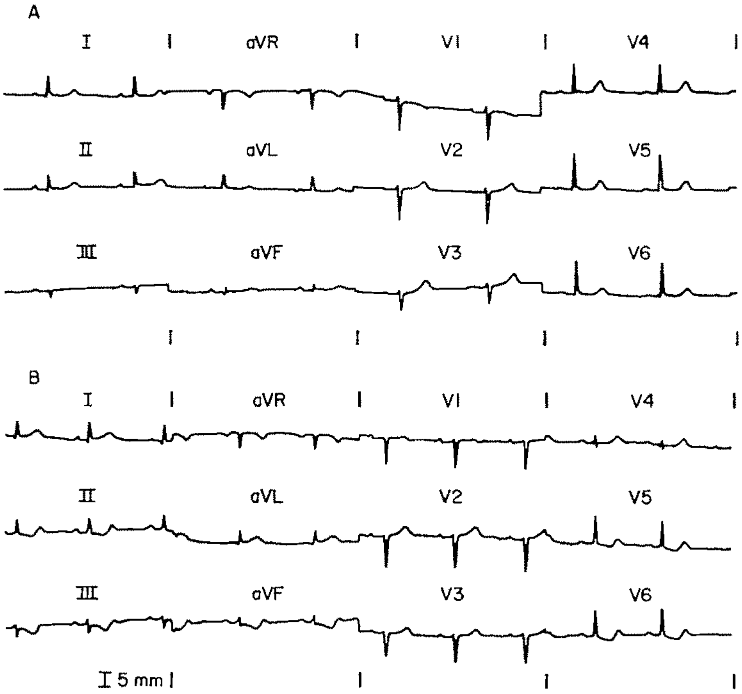

Fig. 1. (A) pre-operative ECG and (B) ECG during chest pain showing ST depression and T wave inversions in the inferior leads.

intravenously. The patient complained of intense substernal chest pressure in addition to right facial pain shortly after the glycerol injection. Oxygen and sublingual nitroglycerin 0.6 mg had little effect on her chest pain. Her blood pressure returned to normal within approximately 10 minutes but her chest discomfort continued for another 30 minutes. A 12-lead ECG obtained 15 minutes after the onset of chest pain demonstrated 1 mm of downsloping ST depression with T wave inversions in leads II, III and aVF, which all represented changes from her baseline ECG (Fig. 1).

The patient was admitted directly to the coronary care unit after operation. Subsequent ECGs and serial creatine phosphokinase (CPK) determinations were diagnostic of a non-Q wave infarction with a peak CPK of 684 IU/litre (5% MB fraction). The patient underwent coronary angiography on the second postoperative day because of continued episodes of chest pain poorly responsive to intravenous nitroglycerin. Catheterisation showed anatomically normal coronary arteries and inferior wall dyskinesis. Ergonovine challenge demonstrated localised spasm of the right coronary artery and associated chest pain. The patient was treated subsequently with diltiazem and experienced no further episodes of chest pain. She was discharged from the hospital on the 10th day after operation.

Discussion

Percutaneous electrocoagulation and glycerol rhizotomy are the two most commonly used destructive procedures performed to treat *tic douloureux*. The relative advantages of the latter include less postoperative facial deafferentation and its sequelae compared with thermal rhizotomy; simplicity; and a high initial success rate. Both procedures, however, are often associated with the acute onset of transient hypertension despite mild to moderate sedation. Mean arterial pressures as high as 200 mmHg have been documented in the literature.[2]

The aetiology of this hypertension is not clear. It may be related to the light levels of anaesthesia that are used to facilitate patient communication with the surgeon regarding the intensity and quality of pain and pain relief. Attempts to deepen anaesthesia with narcotics and nitrous oxide, however, have not blocked this hypertensive response.[3] Alternatively, it is postulated that stimulation of the trigeminal ganglion may elicit directly a profound sympathetic discharge. This latter concept is supported by anatomical studies in animals which demonstrate connexions between the Gasserian ganglion and the autonomic nervous system.[4] These brief periods of hypertension and tachycardia are usually well tolerated in an otherwise healthy patient. However, ventricular premature beats and one episode of severe epistaxis were described by Kehler *et al.* in a series of 11 patients who underwent radiofrequency trigeminal rhizotomies.[2] Such sudden increases in afterload and in myocardial oxygen consumption may also precipitate myocardial ischaemia in patients with coronary artery stenoses. Furthermore, the present case suggests that this sympathetic stimulus may result in ischaemia in patients prone to coronary artery vasospasm.

Myocardial ischaemia and infarction are well-documented events in patients with anatomically normal coronary arteries.[5] Coronary spasm is presumed to represent the underlying pathophysiology. In patients prone to vasospasm, increases in sympathetic tone during trigeminal ganglion stimulation may promote spasm, ischaemia and infarction, as occurred in this patient. Attempts to attenuate this pressor response have included beta-adrenergic blockers.[3] Beta-blockade, however, may precipitate coronary spasm in some patients and worsen ongoing spasm in others. Vasodilators such as trimethaphan and sodium nitroprusside are also employed for this purpose.[2] Therapy with these potent agents usually necessitates use of continuous intra-arterial pressure monitoring. Recently, it has been demonstrated that cutaneous nitroglycerin ointment modifies significantly the hypertensive response induced by electroconvulsive therapy.[6] Such treatment is relatively simple and used prophylactically may help prevent myocardial ischaemia in patients with fixed coronary lesions and in those with a history of coronary vasospasm who present for trigeminal rhizotomy. Calcium antagonists may offer a further means of blunting hypertension and spasm during rhizotomy.

In conclusion, we describe a case of coronary vasospasm and myocardial infarction in a patient who underwent percutaneous trigeminal rhizotomy. Patients with a history of coronary spasm probably represent higher risks for this procedure and pre-operative therapy with nitroglycerin and calcium antagonists as well as invasive intra-operative monitoring may be useful to decrease the incidence of complications in this group of patients.

References

1. WILKINS RH. Trigeminal neuralgia. In: WILKINS RH, RENEGACHARY SS, eds. *Neurosurgery*. New York: McGraw-Hill, 1984: 2337–44.
2. KEHLER CH, BRODSKY JB, SAMUELS SI, BRITT RH, SILVERBERG GD. Blood pressure response during percutaneous rhizotomy for trigeminal neuralgia. *Neurosurgery* 1982; **10**: 200–2.
3. KNITZA R, OLBERMANN M, FISCHER F, BASSLER KH. Kreislaufverhalten, Blutgase, Säure-Basen- und Stoffwechselveränderungen unter Neuroleptanalgesie mit und ohne Betarezeptorenblocker bei der Elektrokoagulation des Ganglion Gasseri. *Anaesthesist* 1978; **27**: 213–8.
4. KUMADA M, DAMPNEY RA, REIS DJ. The trigeminal depressor response: a novel vasodepressor response originating from the trigeminal system. *Brain Research* 1977; **119**: 305–26.
5. OLIVA PB. The role of coronary artery spasm in acute myocardial infarction. *Cardiovascular Clinics* 1983; **14**: 45–58.
6. LEE JT, ERBGUTH PH, STEVENS WC, SACK RL. Modification of electroconvulsive therapy induced hypertension with nitroglycerin ointment. *Anesthesiology* 1985; **62**: 793–6.

Anaesthesia, 1988, Volume 43, pages 864–866

CASE REPORT

A boy with an anterior mediastinal mass

R. E. JOHN AND V. P. S. NARANG

Summary

A 12-year-old boy presented for biopsy of a large mediastinal mass. General anaesthesia precipitated immediate severe airway obstruction. This was overcome by the insertion of two microlaryngeal tubes, one into each main bronchus. The anaesthetic management of patients with an anterior mediastinal mass is discussed and the importance of pre-operative assessment stressed.

Key words

Intubation, tracheal; complications.

The presence of an anterior mediastinal mass may be associated with severe cardiorespiratory complications.[1–3] These include airway occlusion, loss of lung volume, superior vena caval obstruction and pulmonary artery or cardiac compression. General anaesthesia in such patients is dangerous and may prove fatal.

We describe a case in which potentially fatal difficulties arose, and the method adopted to overcome them.

Case history

A 12-year-old boy was admitted with a history of progressive shortness of breath. He was previously fit and healthy and had been playing competitive soccer up until 5 days before admission. Shortness of breath occurred only on strenuous exercise and came to his attention when it prevented him from finishing a game. He had also noticed some prominent veins on his upper chest. On examination, he was well built, there were dilated veins in his neck and over his left upper chest, and a few small cervical lymph nodes were noted. Hepatosplenomegaly was present. The only abnormality in the respiratory system was that he could manage only two or three ineffective grunts when asked to cough. A chest X ray showed a large anterior mediastinal mass. This was confirmed by computerised tomography (CT); four 'cuts' were made through the mediastinum but no airway narrowing was demonstrated.

It was suspected that he had a T-cell lymphoma, but peripheral blood film, bone marrow aspiration and a trephine biopsy all failed to provide conclusive evidence. It was thought that the best way to obtain a definite histological diagnosis was by biopsy of the mediastinal mass. The dangers of general anaesthesia were discussed but it was considered that the procedure could not be performed under local anaesthesia.

A full range of uncut tracheal tubes and a ventilating bronchoscope were made available in addition to all the usual preparations for general anaesthesia. The patient was not premedicated. An intravenous infusion was established under local anaesthesia, and noninvasive automatic blood pressure and electrocardiographic monitoring were instituted. Anaesthesia was induced with an inhalational technique, with oxygen and halothane. He developed both inspiratory and expiratory stridor as the level of anaesthesia deepened, and then became completely obstructed. Tracheal intubation was achieved without difficulty with an uncut 7.0 mm Portex tracheal tube, although the level of anaesthesia was not very deep. The tube was inserted to a point where resistance to further passage was noted. His respiratory efforts ceased and his lungs could not be ventilated manually, despite confirmation of the correct placement of the tracheal tube by laryngoscopy. He became cyanosed and developed runs of ventricular ectopic beats. Vecuronium was given in the hope that it might facilitate ventilation, but there was no improvement.

The tracheal tube was pushed forcibly further down past the point of resistance in an attempt to pass a presumed obstruction, and it was then possible to ventilate the right lung, but not the left. Various manipulations of the tube were attempted, but these resulted either in complete obstruction or ventilation of the right lung only. The patient remained cyanosed, but the pulse and arterial pressure were stable. Manual ventilation was continued with 100% oxygen and halothane. The surgeon was asked to pass a rigid bronchoscope to help identify the cause and site of the airway obstruction. A 5-mm Negus bronchoscope was used; there was total collapse of the distal trachea, carina and proximal 2 cm of both main bronchi.

The bronchoscope could be inserted past the obstruction

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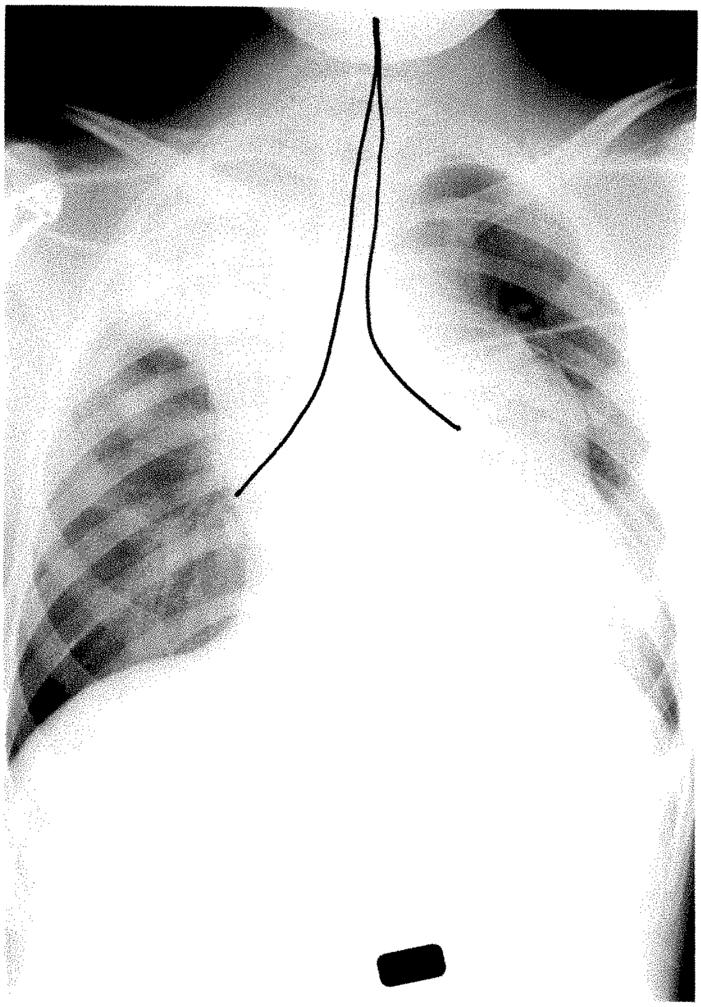

Fig. 1. The chest X ray appearance on the third postoperative day. The markers in the bronchial tubes are outlined. The mediastinal mass and the right upper lobe collapse and consolidation can be seen.

in either bronchus, but it was possible to ventilate only one lung at a time. Cyanosis could be prevented only by ventilating the left and the right lungs alternately, changing about every 3 minutes. It was thought that airway collapse might improve on return of spontaneous ventilation. Consequently, neuromuscular blockade was reversed, and the patient was allowed to breathe spontaneously with the bronchoscope above the obstruction. The walls of the trachea remained collapsed despite good respiratory efforts, and cyanosis recurred rapidly; he was paralysed again and ventilated as before. Eventually, two Portex microlaryngeal tubes were passed, one distal to the obstruction in each main bronchus. They were introduced over bougies positioned by the surgeon under direct vision through the bronchoscope. These were the only tubes which were narrow enough to pass through the larynx together, yet long enough to pass the obstruction. They were connected to a double lumen catheter mount, as used for double lumen bronchial tubes. It was then possible for the first time in over an hour to ventilate both lungs at the same time. Awareness was prevented by the use of halothane throughout.

An open biopsy of the mass was performed through an anterior mediastinotomy. Sedation, paralysis and ventilation were maintained because of the major airway problems that had been encountered, and the patient was transferred to the intensive care unit with both bronchial tubes in position. A chest X ray showed right upper lobe collapse, caused probably by the tube obstructing the upper lobe bronchus; it was not withdrawn for fear of displacing it or the other tube. Adequate oxygenation was achieved with inspired oxygen concentrations of 50% or less. Chemotherapy was started immediately and histology subsequently confirmed the diagnosis of T-cell lymphoma.

There was no radiological evidence of any shrinkage of the mass until the fifth postoperative day. The microlaryngeal tubes were then withdrawn carefully under direct vision, using a 4-mm fibreoptic bronchoscope. The appearance was of persistent, but incomplete, tracheobronchial compression. However, it was possible to ventilate both lungs through a single 7.0-mm tracheal tube. The trachea was extubated uneventfully next day.

He was discharged home after a further 2 weeks in hospital, and suffered no long-term sequelae from either the anaesthetic or his stay in the intensive care unit. At present he is continuing his chemotherapy.

Discussion

Patients, and especially children, with mediastinal masses present grave risks during the peri-operative period.[3-7] Those with respiratory symptoms, or other evidence of tracheal compression, may develop total airway obstruction during the course of general anaesthesia. Obstruction can appear for the first time, or worsen, during anaesthesia; the problem may persist during emergence.[1-3,8] In our case, the only solution was the use of two separate bronchial tubes. It should be stressed that fashioning a tracheostomy would have been futile.[1]

A thorough pre-operative assessment is essential, but the severity of symptoms is not a reliable indicator of the degree of compromise; a number of asymptomatic patients have developed severe airway obstruction during anaesthesia.[9] Pre-operative chest X rays, both posteroanterior and lateral, may give the first suggestion of airway compression. CT scans of the thorax should also be performed, using small contiguous cuts.[2] Flow-volume loops have been recommended to demonstrate the changes in flow rates at different lung volumes;[9-10] airway obstruction may vary with the respiratory cycle and the position of the patient.[1] Echocardiography should also be performed pre-operatively to evaluate myocardial contractility and to assess the degree of involvement by tumour of the heart and great vessels.

There is debate about the value of awake fibreoptic bronchoscopy before anaesthesia; some authors recommend it to assess the obstruction in older children,[1,3] but others find that it is unhelpful and suggest that it is hazardous if the airway is already compromised.[2]

Blood films, bone marrow aspirates or trephine biopsies should be used initially for diagnosis in the patient who presents with airway obstruction caused by a mediastinal mass. Lymph node biopsy should be carried out under local anaesthesia if possible. Empirical pretreatment is required if this cannot be done and the patient presents a grave risk for general anaesthesia; radiotherapy and chemotherapy, including the use of steroids alone, have been used. The same therapeutic measures have also been used after obstruction has been precipitated by anaesthesia. A patient with airway obstruction caused by a tumour that is not sensitive to pretreatment presents the most difficult problem.

The anaesthetic technique starts with securing intravenous access, with a large bore cannula; this must be inserted in the lower limb if superior vena caval obstruction is present. The patient must be allowed to breathe spontaneously until the airway is secured; muscle relaxants must be avoided until this has been achieved since it may be impossible to ventilate the lungs with a mask or to pass a tracheal tube beyond the obstruction. The use of the lateral or prone position may help to relieve obstruction, as may the application of positive end-expiratory pressure by way of the mask.[10] Such manoeuvres may also be helpful after extubation. The ready availability of uncut tracheal tubes and a ventilating bronchoscope proved invaluable in our case. Some recommend that the facility for femoro-femoral cardiopulmonary bypass should be available immediately for all high risk patients.[1,2]

In retrospect, we should have expressed stronger misgivings about providing general anaesthesia for this patient. Further CT studies and flow-volume loops might have been useful. This boy had symptoms suggestive of airway compromise and also had evidence of superior vena caval obstruction. Biopsy performed under local anaesthesia, or empirical pretreatment, would have been preferable.

Acknowledgments

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References

1. Newman GG, Weingarten AE, Abramowitz RM, Kushins LG, Abramson AL, Ladner W. The anesthetic management of the patient with an anterior mediastinal mass. *Anesthesiology* 1984; **60:** 144–7.
2. Azizkhan RG, Dudgeon DL, Buck JR, Colombani PM, Yaster M, Nichols D, Civin C, Kramer SS, Haller JA Jr. Life-threatening airway obstruction as a complication to the management of mediastinal masses in children. *Journal of Pediatric Surgery* 1985; **20:** 816–22.
3. Mackie AM, Watson CB. Anaesthesia and mediastinal masses. A case report and review of the literature. *Anaesthesia* 1984; **39:** 899–903.
4. Bittar D, Respiratory obstruction associated with induction of general anesthesia in a patient with mediastinal Hodgkin's disease. *Anesthesia and Analgesia* 1975; **54:** 399–403.
5. Keon TP. Death on induction of anesthesia for cervical node biopsy. *Anesthesiology* 1981; **55:** 471–2.
6. Halpern S, Chatten J, Meadows AT, Byrd R, Lange B. Anterior mediastinal masses: anesthesia hazards and other problems. *Journal of Pediatrics* 1983; **102:** 407–10.
7. Lokich HH, Goodman R. Superior vena cava syndrome: clinical management. *Journal of the American Medical Association* 1975; **231:** 58–61.
8. Bergman NA. Reduction in resting end-expiratory position of the respiratory system with induction of anesthesia and neuromuscular paralysis. *Anesthesiology* 1982; **57:** 14–7.
9. Piro AJ, Weiss DR, Hellman S. Mediastinal Hodgkin's disease: a possible danger for intubation anesthesia. Intubation danger in Hodgkin's disease. *International Journal of Radiology Oncology and Biological Physics* 1976; **1:** 415–9.
10. Abramson AL, Goldstein MN, Stenzler A, Steele A. The use of the tidal breathing flow volume loop in laryngotracheal disease of neonates and infants. *Laryngoscope* 1982; **92:** 922–6.
11. Miller RD, Hyatt RE. Evaluation of obstructing lesions of the trachea and larynx by flow-volume loops. *American Review of Respiratory Disease* 1973; **108:** 475–81.

Anaesthesia, 1988, Volume 43, pages 867–869

CASE REPORT

Spina bifida occulta and epidural anaesthesia

E. M. McGRADY AND A. G. DAVIS

Summary

Spina bifida occulta occurs in 5–10% of the population, not all of whom display superficial signs. Attempted epidural puncture at the level of the lesion will almost certainly result in a dural tap. We report a patient who developed a postural headache after Caesarean section under epidural anaesthesia, in whom radiography of the spine later demonstrated spina bifida occulta. This problem has not been described previously, although it is unlikely to be an isolated case.

Key words

Anaesthetic techniques, regional; epidural.
Complications; headache, spina bifida occulta.

Spina bifida presents in three per 1000 live births, although 40% die in the first year of life.[1] Five to ten percent of the population may have spina bifida occulta, a minor bony defect in the spinous process and laminae, with no neurological deficit.[2] This is often noticed incidentally on radiography of the spine. Bromage[3] reports that attempted epidural puncture at the level of the lesion will inevitably result in dural tap because of the absence of an epidural space. Superficial signs of the lesion, which are not invariably present but which should arouse suspicion, include a tuft of hair, cutaneous angioma, lipoma, or a skin dimple.

A primigravid mother is described who presented for elective Caesarean section under epidural analgesia and who had unsuspected spina bifida occulta.

Case history

A 23-year-old insulin-dependent diabetic was scheduled to undergo elective Caesarean section at 37 weeks' gestation. Antenatal diabetic control had been poor and there was some anxiety about fetal abnormality on scan; a plain abdominal film did not confirm this. She was tense and anxious, and uncooperative when requested to flex the spine. Her spinous processes were not readily palpable although she was slim. Initially, epidural puncture was attempted at what was judged to be the $L_{2/3}$ interspace, but the needle contacted bone. When redirected, at a depth of 2 cm, the mother suddenly jumped up and backwards, complaining of an 'electric shock down the left side'. The needle, with stillette *in situ*, was withdrawn immediately.

A repeat attempt to locate the epidural space, 2 cm lower, was successful. The inter-spinous ligament felt unusually soft and there was an almost immediate loss of resistance at 3 cm on advancing the needle. The epidural catheter was inserted with ease, and a total dose of 2% lignocaine 21 ml with 1 in 200 000 adrenaline resulted in an adequate block to T_4. Caesarean section was uneventful and a 3.1 kg baby was delivered with an Apgar score of 9 at one minute. Fentanyl 100 μg in 10 ml sodium chloride was administered epidurally at the end of the procedure.

Progress was satisfactory until the second postoperative day when the mother developed a postural headache. Dural tap was unsuspected at the time, although the headache was very typical; it was thought to have occurred when the patient jumped backwards suddenly. It was then revealed that pre-operative abdominal radiography had shown 'maternal spina bifida occulta of the dorsolumbar region'. Its significance with regard to epidural anaesthesia was not appreciated although noted by obstetricians before filing the report.

A blood patch was undertaken; an initial attempt at the level of the previous successful epidural approach resulted in clear fluid dripping back down the needle, which was deemed to be cerebrospinal fluid (CSF) on temperature and glucose testing; it was assumed that dura had again been punctured. A blood patch was successfully performed 4 cm lower, (at what was thought to be the $L_{3/4}$ interspace) and 20 ml blood injected. The headache improved over 24 hours, with a mild recurrence on the fourth day. A complaint of blurred vision drew attention to a partial sixth nerve palsy.

Postnatal radiography of the lumbar spine was under-

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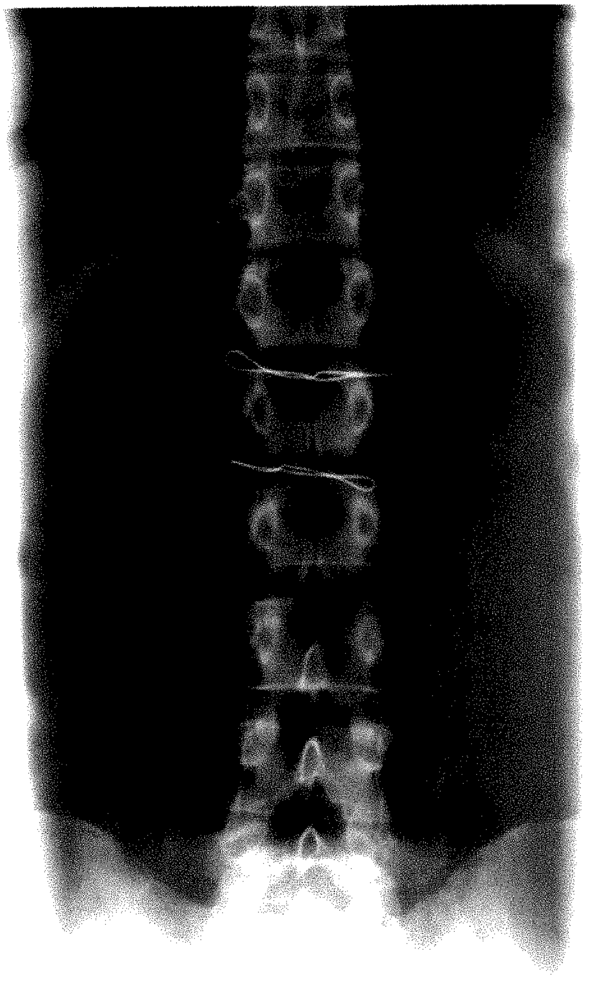

Fig. 1(a). Spina bifida occulta from T_{11} to L_2. Markers over sites of attempted (upper) and successful (lower) epidural.

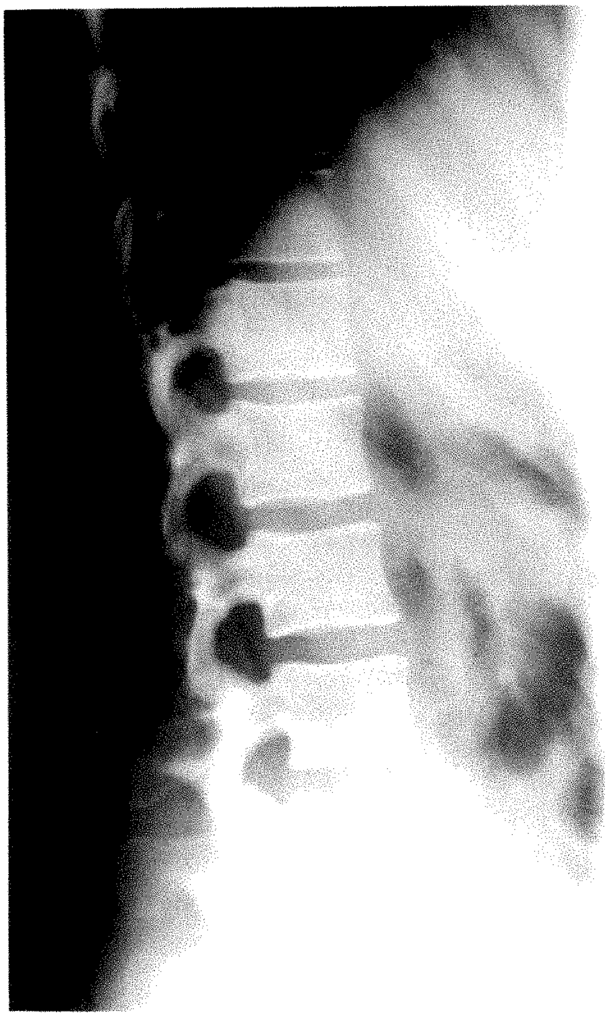

Fig. 1(b). Lateral film displays absent spinous processes.

taken, with markers over the sites of attempted epidural puncture (Fig. 1(a)). Surprisingly, the site of puncture was higher than judged; the upper marker is over the site of the initial attempt at T_{12}/L_1 interspace, and the lower marker, over $L_{1/2}$ interspace shows the site of the successful epidural. The extent of the lesion is seen to be T_{11} to L_2. The absence of spinous processes is noted on a lateral film (Fig. 1(b)).

Discussion

Spina bifida occulta occurs most frequently in lower lumbar and sacral vertebrae; the incidence at a higher level is not known. Most are recognised on routine radiography and the number without cutaneous stigmata is again unclear. Presumably this is not an isolated case, although we have found no previous reports in the literature. Epidural analgesia has been utilised during labour in a patient with spina bifida cystica; the epidural was sited above the lesion and only 0.25% bupivacaine 6 ml provided analgesia to T_6.[4]

The anatomy at the level of the lesion is unclear. Ingraham[5] describes lobules of fat lying in the midline, adherent to adjacent fascia and dura while Bromage[3] concludes that the epidural space is virtually obliterated. However, our epidural was sited within the limits of the lesion (Fig. 1(a)) and the spread of local analgesia and dose required were entirely normal. It cannot be a constant feature throughout the extent of the lesion if the epidural space is absent. The flow of CSF suggested a repeat dural puncture when a blood patch was attempted at the same level. However this may have been CSF lying in the epidural space after the initial puncture as described by Cucchiara and Wedel.[6] Blood patch improved the headache; presumably the epidural space was not completely absent at the site of dural puncture, or the blood would not have stopped CSF leakage.

This was an interesting and informative case. Had a prenatal abdominal film not been available we would have assumed the mother to have experienced an inadvertent rather than an inevitable dural tap, and no further investigation would have been carried out. It might be interesting, if not advisable, to X ray the spine and exclude the lesion, if an expereinced anaesthetist is surprised to puncture dura, particularly if the anatomy feels unusual. Its presence does not contraindicate epidural analgesia, provided it is inserted beyond the extent of the lesion. The patient might benefit in future pregnancies and in attempts to perform a blood patch.

References

1. Duthrie RB, Ferguson AB. Mercer's orthopaedic surgery. 7th edn, London: Edward Arnold, 1973: 179.
2. Rothman RH, Simeone FA. *The spine*, 2nd edn. Vol. I. Philadelphia: W.B. Saunders, 1982: 241.
3. Bromage PR. *Epidural analgesia*. Philadelphia: W.B. Saunders, 1978: 707–8.
4. Vaagenes P, Fjaerestad I. Epidural block during labour in a patient with spina bifida cystica. *Anaesthesia* 1981; **36:** 299–301.
5. Ingraham FC. *Spina bifida and cranium bifidum*. Massachusetts: Harvard University, 1944: 44.
6. Cucchiara RF, Wedel DJ. Finding cerebrospinal fluid during epidural blood patch: how to proceed. *Anesthesia and Analgesia* 1984; **63:** 1121–3.

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CASE REPORT

An unusual case of stridor

A. BLACK AND A. R. LLOYD-THOMAS

Summary

A case is reported in which stridor was the presenting symptom of acute superior vena cava obstruction, after attempted insertion of a Hickman catheter.

Key words

Complications; central venous cannulation, stridor.

Prolonged central venous cannulation with silicone catheters, is frequently employed in patients who require long term supportive therapy.[1,2] There is, however, a significant morbidity associated with their use, including infection (20–30%) and thrombosis of the cannulated vein (5–10%). This thrombosis may spread to involve the great veins and result in the syndrome of superior vena cava obstruction which is characterised by venous dilatation, oedema and plethora of the upper thorax and neck. Conjunctival oedema, headache, altered consciousness and obstruction of the airways and oesophagus, have also been reported.[3] We report a case in which stridor was the presenting symptom of acute caval obstruction after repeated attempts at cannulation with a silicone catheter.

Case history

A 14-month-old male infant, who was undergoing bone marrow transplantation for β-thalassaemia major, presented for re-insertion of a Hickman catheter under general anaesthesia. Three weeks previously the superior vena cava had been cannulated using a similar catheter introduced by surgical cut down through the right internal jugular vein. However, 10 days after this operation, the catheter entry site became infected and this spread to involve the neck. Blood cultures taken from the line grew *Staphylococcus aureus* but despite appropriate antibiotic therapy his pyrexia persisted, the swelling increased in his neck and he was noted to have a hoarse voice with mild stridor on crying. Both his temperature and neck inflammation resolved after removal of the catheter.

He was clinically well at the time of the second operation, there was no stridor or other evidence of upper airway obstruction. Anaesthesia was induced with cyclopropane in oxygen, followed with suxamethonium 20 mg which was administered to facilitate tracheal intubation. The larynx was noted to be normal, a size 4.0 red rubber Magill orotracheal tube passed easily and there was a low-pressure gas leak around the tube. Anaesthesia was maintained by nitrous-oxide (66%) in oxygen with 0.5% halothane given by intermittent positive pressure ventilation of the lungs. Increments of atracurium and fentanyl were given as required.

A silicone catheter was introduced after surgical cutdown onto the left internal jugular vein. Under image intensifying X ray control the catheter was advanced into the brachiocephalic vein. However, despite repeated attempts it would not pass into the superior vena cava (SVC), but preferred instead to enter the azygous vein or the right subclavian vein. Subsequently, a further cut down onto the right femoral vein was performed and the catheter was easily passed into the right atrium by way of the inferior vena cava. Residual neuromuscular block was antagonised by the administration of neostigmine and atropine and the child's trachea was extubated when he was awake.

He developed mild stridor within 4 minutes of tracheal extubation. Over the next 20 minutes, despite the administration of humidified oxygen, dexamethasone (0.2 mg/kg) and finally nebulised adrenaline, the severity of the stridor increased. Furthermore, he began to develop facial and conjunctival oedema. He became tachypnoeic (respiratory rate 60 breaths per minute), marked intercostal recession, tracheal tug and sternal depression were also seen. There was no wheeze, his blood pressure was well maintained and the developing oedema was confined to the drainage area of the SVC. A provisional diagnosis of oedematous upper airway obstruction from superior vena caval syndrome was made. Anaesthesia was re-induced with halothane in

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oxygen and at laryngoscopy the arytenoids and supraglottic structures were noted to be markedly oedematous. Moreover, only a size 3.0 orotracheal tube could be passed and this had a minimal high pressure gas leak. There was immediate relief of the respiratory obstruction. The child was transferred to the intensive care unit and was reintubated with a size 3.0 Portex nasotracheal tube also with a minimal gas leak. The facial, conjunctival and periorbital oedema continued to accumulate and the next morning, when there had been considerable resolution of the oedema, there was only some residual periorbital swelling present.

Laboratory investigations were all normal apart from a haemoglobin of 7.2 g/dl. An echocardiogram showed free flow in the inferior vena cava but no flow from superior vena cava to right atrium and there were multiple bright echos, which suggested intraluminal obstruction. He was treated with antibiotics (gentamicin, ceftazidine, flucloxacillin and metronidazole), dexamethasone and full heparinisation. His lungs were mechanically ventilated for 18 hours after operation and thereafter he breathed spontaneously with continuous positive airway pressure (CPAP) for 48 hours whilst the oedema resolved. His trachea was extubated when a significant low pressure gas leak had developed around the nasotracheal tube. There was still some mild inspiratory stridor which resolved over the next 48 hours after further dexamethasone and nebulised adrenaline. He recovered quickly from this acute episode, but venous dilatation was apparent on the upper chest for 2 months and he also developed facial oedema if allowed to sleep without elevation of his head.

Discussion

Thrombotic processes can be demonstrated in up to 90% of patients in whom central venous cannulation is undertaken with a polyvinylchloride catheter; the most frequent is a fibrin sheath with platelet thrombi attached to the outside of the catheter.[4] In 13% of cases a mural thrombus and in 5% pulmonary emboli can be demonstrated angiographically. Broviac[1] chose siliconised rubber to construct a catheter for long term use, because it is flexible, chemically inert and antithrombogenic. However, at postmortem six out of 10 patients in his series[1] had a fibrin sheath attached to the catheter and there is increasing evidence that the incidence of thrombotic complications (mural thrombus, caval obstruction and pulmonary emboli) is greater than originally thought expecially in patients with catheter associated sepsis.[5–7]

The first catheter inserted in our patient became infected and he had culture positive septicaemia. A mural thrombus in the SVC may have formed as a result of this infection and the difficulty experienced in trying to thread the second catheter into the SVC suggests that a substantial portion of the lumen may have been occluded. The thrombus may then have been dislodged by the catheter tip, which resulted in total SVC obstruction. Pre-operatively venography to demonstrate the patency of the proposed vascular access point has been recommended in adult patients who have had multiple previous central venous catheters.[7] In our patient peripheral venous access was extremely difficult making successful venography unlikely; furthermore he had only one previous catheterisation and at the time of the second operation had no symptoms or signs suggestive of SVC obstruction. However, children may be more susceptible to thrombotic occlusion of central veins after cannulation and partial caval thrombosis may not be recognised clinically.[5,8] A noninvasive assessment of caval patency, such as Doppler or echocardiography, may therefore help in choosing the correct route for repeated central vein cannulation in children.

Stridor is unusual as the presenting symptom in patients with SVC obstruction although it is described in patients with extensive oedema in the drainage area of the SVC. In our patient severe stridor was the presenting symptom, followed by conjunctival and then facial oedema. Minor degrees of mucosal oedema can result in a marked diminution of the glottic lumen in children. This patient, in whom stridor was present during the first episode of infection, appears to be unduly susceptible to this narrowing. Angioneurotic oedema can result in stridor,[9] however, we cannot identify any agents, given shortly before the onset of stridor, which could have precipitated an allergic response in this child. Furthermore, the diagnosis of SVC obstruction is supported by the findings on echocardiography and the subsequent clinical course.

In conclusion, we have presented a case in which stridor was the first manifestation of acute superior vena caval obstruction after attempted cannulation. Caution should be exercised during repeat cannulation of the SVC, especially if there has been a recent episode of infection which increases significantly the chance of thrombosis in the great vessels. Pre-operative investigation may be required to demonstrate free flow in the vein chosen for repeat cannulation.

References

1. Broviac JW, Cole JJ, Scribner BH. A silicone rubber atrial catheter for prolonged parenteral alimentation. *Surgery, Gynecology and Obstetrics*, 1973; **136:** 602–6.
2. Hickman RO, Buckner CD, Clift RA, Sanders JE, Stewart P, Thomas ED. A modified right atrial catheter for access to the venous system in marrow transplant recipients. *Surgery, Gynecology and Obstetrics* 1979; **148:** 871–5.
3. Issa PY, Brihi ER, Janin Y, Slim MS. Superior vena cava syndrome in childhood: report of ten cases and review of the literature. *Pediatrics* 1983; **71:** 337–41.
4. Ahmed N, Payne RF. Thrombosis after central venous cannulation. *Medical Journal of Australia* 1976; **1:** 217–20.
5. Stricker PD, Manoharan A, Hanel KC. Major venous thrombosis in patients with indwelling venous access catheters. *Medical Journal of Australia*, 1986; **144:** 601–3.
6. Mulvihill SJ, Fonkalsrud EW. Complications of superior versus inferior vena cava occlusion in infants receiving central total parenteral nutrituon. *Journal of Paediatric Surgery* 1984; **19:** 752–7.
7. Lazarus HM, Lowder JN, Herzig RH. Occlusion and infection in Broviac catheters during intensive cancer therapy. *Cancer* 1983; **52:** 2342–8.
8. Verghese A, Widrich WC, Arbeit RD. Central venous septic thrombophlebitis—the role of medical therapy. *Medicine* 1985; **64:** 394–400.
9. Valman HB. Stridor. *British Medical Journal* 1981; **283:** 294–5.

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CASE REPORT

Systemic air embolism during laser bronchoscopy

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Summary

We report a case of massive, fatal, systemic gas embolism which occurred during the course of laser bronchoscopic resection of a bronchial carcinoma. The clinical features of systemic air embolism are discussed.

Key words

Complications; air embolus.
Surgery; laser.

In the first half of this century, when induction of artificial pneumothorax was employed frequently in the treatment of pulmonary tuberculosis, systemic air embolism by way of the pulmonary vein was a well recognised hazard.[1] We suggest that this hitherto extremely rare surgical complication may be seen more often, as a result of increased use of laser bronchoscopic resection for the relief of airways obstruction in cases of advanced bronchial carcinoma. Laser bronchoscopy brings together three risk factors for the entry of gas into the pulmonary vein, namely pulmonary instrumentation under conditions of limited vision, intrathoracic gas at superatmospheric pressure and a pathological process which consolidates the lungs and encircles the pulmonary veins.

Case history

A female patient, aged 68 years, who had been a lifelong smoker and who was known to have a poorly differentiated squamous bronchial carcinoma, for which she had received a course of radiotherapy, presented with a 6-week history of haemoptysis and increasing breathlessness. On examination she was dyspnoeic at rest and had a loud wheeze audible in both inspiration and expiration. Her chest radiograph revealed an opacity in the superior mediastinum which extended into the right upper zone; there was partial collapse of the right upper lobe. Bronchoscopy confirmed the presence of a tumour at the carina, which narrowed the right main bronchus to a pinhole and the left to approximately 50% of its normal calibre. It was decided to undertake laser bronchoscopic resection of this tumour in the hope of palliating the patient's obstructive symptoms.

The patient was premedicated with oral temazepam 20 mg and atropine 0.6 mg one hour before the procedure. ECG monitoring was instituted on her arrival in theatre; a pulse oximeter was placed on her finger and a radial artery cannula inserted using local anaesthetic. An intravenous cannula was inserted into each arm and anaesthesia induced with fentanyl 100 μg and propofol 150 mg and maintained by an infusion of the latter at a rate of 10 mg/minute. An 8-mm Portex cuffed tracheal tube was inserted with the aid of suxamethonium 100 mg and paralysis was maintained with atracurium 25 mg; further doses were given as indicated by a peripheral nerve stimulator. A fibre-optic bronchoscope was inserted through an airtight port in the catheter mount and the patient's lungs were ventilated manually with a 10 litre/minute flow of oxygen-enriched air using a non rebreathing circuit (Fig. 1). A smoke absorption device (made from two Pall gas filters between which a layer of granular activated charcoal was sandwiched) was connected to the expiratory limb of the system. The first half hour of the procedure was uneventful from the anaesthetic point of view; the mean arterial pressure was maintained between 100 and 120 mmHg, the pulse rate 90–100 beats/minute and the haemoglobin saturation never decreased below 97%.

Bronchoscopy revealed a mass of tumour which widened the carina and obstructed both main bronchi, the left partially and the right completely. The tumour was largely necrotic and its surface coated with mucopus and old blood. A Messerschmidt Nd. YAG laser operating at 50 watts output was used to widen the right main bronchus sufficiently to permit passage of the bronchoscope into the right lower lobe bronchus.

Torrential bleeding occurred as further tumour was burnt off the medial wall of the right main bronchus. The

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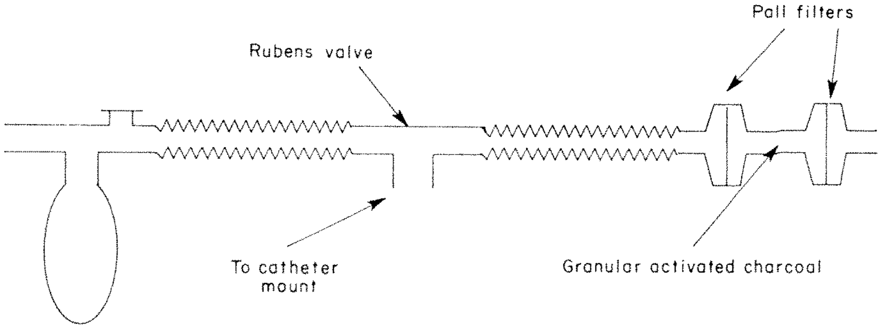

Fig. 1. Diagram of anaesthetic system used for manual ventilation during bronchoscopy.

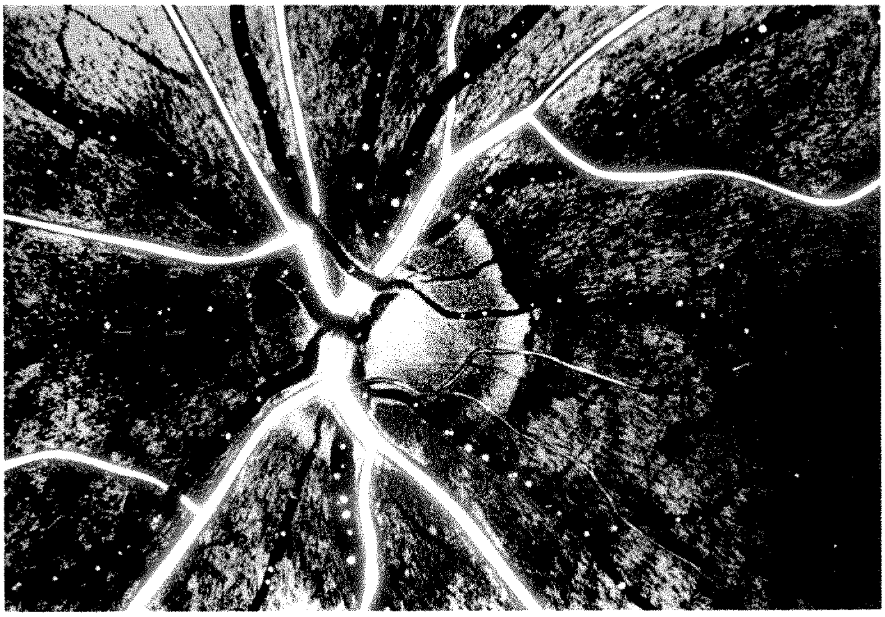

Fig. 2. Artist's impression of retinal appearance after massive systemic air embolism.

patient became acutely hypertensive (mean arterial pressure 180 mmHg) and bradycardic (40 beats/minute). Both pupils became fixed and dilated and marked patchy facial pallor was noted. It was impossible to identify a bleeding point as a result of profuse haemorrhage (500 ml of blood were aspirated by way of the bronchoscopic suction channel over a period of a few minutes). Ventilation became increasingly difficult and in view of suspected hypoxia, the inspired oxygen was increased to 100%; atropine 0.6 mg was given intravenously and an attempt made to pass a left-sided Robertshaw double lumen bronchial tube. It was apparent immediately that this could not be passed beyond the tumour which obstructed the left main bronchus so the tracheal tube was replaced. The patient's bradycardia became worse despite intravenous adrenaline, calcium chloride and further atropine. The hypertension gave way, after 2 minutes, to profound hypotension and external cardiac massage was instituted.

In the course of withdrawing an arterial sample for blood gas analysis (the $Pa\text{O}_2$ was 57 kPa and $Pa\text{CO}_2$ 7 kPa), it was noticed that copious bright red froth was issuing spontaneously from the arterial cannula. Systemic air embolism was suspected; the patient showed generalised intense but mottled pallor, crepitus could be felt along the course of the brachial, femoral and carotid arteries, and a loud millwheel or 'squelchy boot' murmur was audible throughout the chest (although this seemed loudest over the left ventricle). Ophthalmoscopy revealed that the entire retinal arterial tree was outlined with air and bubbles could be seen moving centripetally along the retinal veins (Fig. 2).

The appearance of the fundi was extremely striking; it was as if the arteries had been injected with mercury so that the retina resembled a silver spider's web. It was clear to us that massive systemic air embolism had taken place, presumably because the tumour in the medial wall of the right main bronchus was in continuity with a branch of the pulmonary vein. This had been breached by the laser with the result that air was forced from the bronchus into the systemic circuit by positive pressure ventilation. The patient was tipped head-down; ventilation and cardiac massage were continued for 30 minutes but the bradycardia gave way to asystole refractory to all treatment and our rescusitative efforts had to be discontinued.

Postmortem examination revealed the presence of a mass of tumour tissue which encircled and obstructed both main bronchi and involved the oesophagus and one of the right

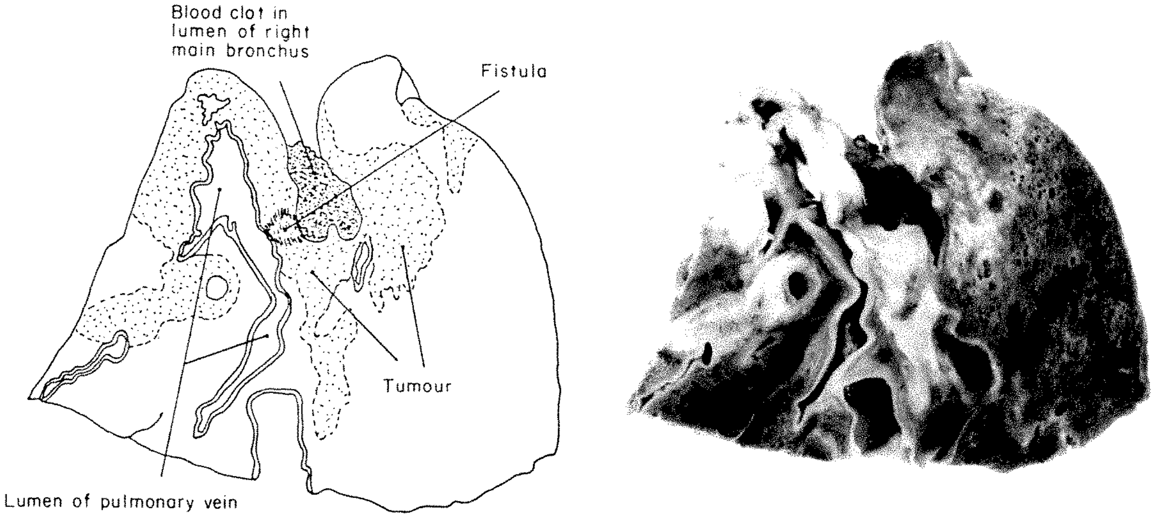

Fig. 3. Posterior aspect of coronal section through upper part of right lung.

pulmonary veins (Fig.3). Dissection revealed a fistula through the tumour, which connected the medial wall of the right main bronchus with a branch of the pulmonary vein. Tumour deposits were also identified in the hilar and mediastinal lymph nodes and in the cervical vertebrae.

Discussion

Systemic air embolism by way of the pulmonary vein has been reported as a complication of pneumonectomy,[2] needle lung biopsy,[3] penetrating lung injury,[4–8] blunt lung injury,[4] high-pressure artificial ventilation in neonates[9] and in particular, the induction of artificial pneumothorax.[1,10–12] Pressure within the pulmonary vein may be intermittently subatmospheric so air can be entrained if the vessel wall is torn in such a way that its lumen is brought into continuity of the atmosphere. This can occur either directly as a result of a penetrating chest wound or indirectly through the airway.

The risk of systemic air embolism is increased considerably if tissues adjacent to the vessel are consolidated, as may occur with a bronchogenic carcinoma or tuberculous process. Normal elasticity of the lung is lost and any abnormal communication, however formed, between the vein and air passages is held open for a longer period than would otherwise be the case. Where such a communication involves the airways, the risk of embolism is greater if the airway pressure is artificially increased, by intermittent positive pressure ventilation, for example. If the communication is with the pleural cavity, a tension pneumothorax would constitute a greater danger than, say, a sucking wound of the chest. It is not surprising therefore that a majority of earlier reports of systemic air embolism concern the creation of artificial pneumothoraces to treat extensive pulmonary tuberculosis, in which two risk factors—an airspace at super atmospheric pressure and abnormally rigid lung tissues coexisted.

Situations most likely to give rise to systemic air embolism by way of the pulmonary vein, in current medical practice, are penetrating lung injuries and surgical procedures on patients with extensive neoplastic or inflammatory pulmonary consolidation in whom intermittent positive pressure ventilation has to be employed. These dangers, during thoracotomy, are usually appreciated and so avoided by the surgeon, but when access is limited severely, as in endoscopic procedures such as laser bronchoscopy, the risk is inherent in the procedure and is therefore largely unavoidable.

Some authorities recommend that laser treatment should be carried out in the spontaneously breathing patient[13–15] (in whom systemic air embolism is less likely to occur), although a majority favour assisted ventilation[16–23] since it provides a more tranquil operating field, avoids hypoxia as a result of respiratory depression and only rarely causes complications.[24]

Systemic air embolism is probably an extremely rare event; few clinicians have seen it and its clinical signs are not well known. Clarke[25] lists four pathognomonic signs: marbling of the skin (which was present in our patient), pallor of half or a portion of the tongue (Leibermeister's sign, because of embolism of all or part of a lingual artery), air bleeding (which was illustrated dramatically by the froth which issued from the radial arterial line in our patient) and bubbles of air in the retinal blood vessels. Clarke goes on to state that the millwheel murmur characteristic of venous air embolism is absent in systemic embolism. This murmur was obviously present in our case: we believe that this may have been because of the relatively large volumes of gas which entered the left side of the heart, as evidenced by the total replacement of retinal arterial blood by gas. Air has been demonstrated to pass from the arterial to the venous circulation[5,26] as is borne out by our observation of bubbles which moved centrally along the retinal veins. However, we consider that in the case described the total volume of gas that passed through the left ventricle must inevitably have exceeded that which reached the right heart. Clinically, the millwheel murmur was louder over the left ventricle.

Systemic air embolism is only rarely diagnosed antemortem.[8] The dramatic, albeit brief, episode of hypertension which marked its occurrence in our patient has only once been commented on in the literature.[12] Van Allen and co-workers noted, in their elegant experimental study of pulmonary venous air embolism in dogs, that brief, extreme hypertension preceded circulatory collapse. It is unlikely that we would have observed the phenomenon had we not employed direct intra-arterial pressure monitoring. The signs of air embolism disappear within a few hours of death and are easily missed at postmortem examination.[9,25]

The principal clinical manifestation of systemic air embolism is circulatory collapse followed by pupillary dilatation. Unless the initial hypertension is noticed, or evidence of intra-arterial air is sought (by skin incision to detect air bleeding or ophthalmoscopy to check for retinal intravascular air) or the episode occurs during thoracotomy (when intra-coronary air may be seen), systemic air embolism may remain unrecognised and death will be attributed to other causes, such as hypoxia, haemorrhage or dysrhythmia.

Treatment remains a problem after the diagnosis. Earlier authors recommend that the patient should be allowed to remain 'in the original position quietly and fight his own battle'.[12] However, a more aggressive approach to management, as described by Yee *et al.*[4] has led to a favourable outcome in the surprisingly large number of cases they have encountered. Immediate thoracotomy should be performed if an episode of systemic air embolism is suspected (by the occurrence of acute hypertension and/or haemoptysis followed by circulatory collapse on commencement of intermittent positive pressure ventilation in a patient with chest trauma). Yee *et al.* advise left ventricular aspiration, if air is found in the coronary arteries, and either cross clamping the hilum of the affected lung or its prompt isolation with a double lumen tracheal tube. The patient should be tipped head down (to encourage any intra-arterial air to migrate to the lower half of the body), ventilation should be with 100% oxygen at minimal inspiratory pressures and surgical isolation of the site of air entry should then be attempted. There may be a place for vasopressors (to increase pulmonary venous pressures) and rapid institution of cardiopulmonary bypass.[27,28] Regrettably, we believe that systemic air embolism had occurred on a massive scale in the case we describe, and that definitive treatment would have been hopeless by the time we had realised what had happened.

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References

1. Capps JA. Air embolism versus pleural reflex as the cause of pleural shock. *Journal of the American Medical Association* 1937; **109:** 852–4.
2. Graham EA. Treatment of pulmonary suppuration. *Annals of Surgery* 1927; **86:** 174–81.
3. Youmans CR, de Groot WJ, Marshall R, Morettin LB, Derrick JR. Needle biopsy of the lung in diffuse parenchymal disease. *American Journal of Surgery* 1970; **120:** 637–42.
4. Yee ES, Verrier ED, Thomas AN. Management of air embolism in blunt and penetrating thoracic trauma. *Journal of Thoracic and Cardiovascular Surgery* 1983; **85:** 661–8.
5. Thomas AN, Roe BB. Air embolism following penetrating lung injuries. *Journal of Thoracic and Cardiovascular Surgery* 1973; **66:** 533–40.
6. Graham JM, Beall AC Jr, Mattox KL, Vaughan GD. Systemic air embolism following penetrating trauma to the lung. *Chest* 1977; **72:** 449–54.
7. Smith JM, Richardson JD, Grover FL, Arom KV, Webb GE, Trinkle JK. Fatal air embolism following gunshot wound of the lung. *Journal of Thoracic and Cardiovascular Surgery* 1976; **72:** 296–8.
8. Cholankeril JV, Joshi RR, Cenizal JS, Ketyer S, O'Connor WT. Massive air embolism from the pulmonary artery. *Radiology* 1982; **142:** 33–4.
9. Rudd PT, Wigglesworth JS. Oxygen embolus during mechanical ventilation with disappearance of signs after death. *Archives of Diseases of Childhood* 1982; **57:** 237–9.
10. Schlaepfer K. Air embolism following various diagnostic or therapeutic procedures in diseases of the pleura and the lung. *Bulletin of the Johns Hopkins Hospital* 1922; **33:** 321–30.
11. Sachs TB. Artificial pneumothorax in the treatment of pulmonary tuberculosis. *Journal of the American Medical Association* 1915; **65:** 1861–6.
12. Van Allen CM, Hrdina LS, Clark J. Air embolism from the pulmonary vein. *Archives of Surgery* 1929; **19:** 567–99.
13. Hunton J, Oswal VH. Anaesthetic management for carbon dioxide laser surgery in tracheobronchial lesions. *Anaesthesia* 1987; **42:** 1222–5.
14. Shapshay SM, Beamis JF Jr. Safety precautions for bronchoscopic Nd-YAG laser surgery. *Otolaryngology, Head and Neck Surgery* 1986; **94:** 175–80.
15. Dumon JF, Shapshay S, Bourcereau J, Cavaliere S, Meric B, Garbi N, Beamis J. Principles for safety in application of neodymium-YAG laser in bronchology. *Chest* 1984; **86:** 163–8.
16. Conacher ID, Paes ML, Morritt GN. Carbon dioxide laser bronchoscopy. *Anaesthesia* 1987; **42:** 511–8.
17. Conacher ID, Paes ML, Morritt GN. Anaesthesia for carbon dioxide laser surgery on the trachea. *British Journal of Anaesthesia* 1985; **57:** 448–50.
18. Duckett JE, McDonnell TJ, Unger M, Parr GVS. General anaesthesia for Nd-YAG laser resection of obstructing endobronchial tumours using the rigid bronchoscope. *Canadian Anaesthetists' Society Journal* 1985; **32:** 67–72.
19. McElvein RB, Zorn GL Jr. Indications, results and complications of bronchoscopic carbon dioxide laser therapy. *Annals of Surgery* 1984; **199:** 522–5.
20. Toty L, Personne C, Colchen A, Vourc'h G. Bronchoscopic management of tracheal lesions using the neodymium yttrium aluminium garnet laser. *Thorax* 1981; **36:** 175–8.
21. Personne C, Colchen A, Leroy M, Vourc'h G, Toty L. Indications and technique for endoscopic laser resections in bronchology. *Journal of Thoracic and Cardiovascular Surgery* 1986; **91:** 710–5.
22. Vourc'h G, Tannieres ML, Toty L, Personne C. Anaesthetic management of tracheal surgery using the neodymium-yttrium-aluminium-garnet laser. *British Journal of Anaesthesia* 1980; **52:** 993–7.
23. Laforet EG, Berger RL, Vaughan CW. Carcinoma obstructing the trachea. Treatment by laser resection. *New England Journal of Medicine* 1976; **294:** 941.
24. Vourc'h G, Le Gall R, Colchen A. Pneumopericardium: an unusual complication of endotracheal laser surgery. *British Journal of Anaesthesia* 1985; **57:** 451–2.
25. Clarke DB. Air embolism. In: McNair TJ, ed. *Hamilton Bailey's emergency surgery*. Bristol: John Wright, 1972: 87–8.
26. Donato AT, Arcinegas E, Lam CR. Fatal air embolism during thoracotomy for gunshot injury to the lung. *Journal of Thoracic and Cardiovascular Surgery* 1975; **69:** 827–9.
27. Spencer FC, Rossi NP, Yu SC, Koepke JA. The significance of air embolism during cardiopulmonary bypass. *Journal of Thoracic and Cardiovascular Surgery* 1965; **49:** 615–34.
28. Justice C, Leach J, Edwards WS. The harmful effects and treatment of coronary air embolism during open-heart surgery. *Annals of Thoracic Surgery* 1972; **14:** 47–53.

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APPARATUS

Differential flow from multihole epidural catheters

I. POWER AND J. THORBURN

Summary

The pressures used in vivo to administer epidural doses of local anaesthetic were recorded for 16- and 18-gauge multihole catheters. Observations were made on 10 patients in labour for each catheter gauge. The pressure range for the 16-gauge catheters was 39.9–266 kPa, with a mean of 167.2 kPa, and for 18-gauge, a range of 53.2–266 kPa, mean, 159 kPa. Similar pressures were then applied in vitro to 10 catheters of each gauge, and the flow of fluid observed from the three holes. For each size of catheter, with increasing pressure, flow appeared at the proximal, then the middle, and finally the distal hole. This emphasises that the effect of epidural doses can vary depending on the pressure of injection, especially if the catheter had been passed partially through the dura.

Key words

Equipment; catheters, epidural.

There have been reports of confusing mixtures of epidural and subarachnoid blocks after insertion of epidural catheters for analgesia in labour.[1] One suggested mechanism to overcome this is that multihole catheters be passed partially through the dura, to leave the distal hole in communication with the cerebrospinal fluid (CSF)[2,3] The character of the blockade may then be determined by the differential exit flows from the three holes in the catheter. For example, a slow rate of injection may give an epidural block when the local anaesthetic exits from the catheter through the proximal hole, and a more rapid rate of injection could cause a portion of the agent to enter the CSF through the distal hole to result in a subarachnoid block.

The purpose of this study was to record pressures generated when epidural top-up doses are administered *in vivo*, and to observe *in vitro* the flow of local anaesthetic from the three holes of a sample group of epidural catheters at these pressures. The hypothesis was that the pressure used in practice to inject local anaesthetic during an epidural top-up could produce a differential flow from the holes in a multihole catheter.

Methods

In vivo study

The pressure generated during routine top-ups in labour was observed by measuring the pressure developed proximal to the bacterial filter when a dose was given from a 60 ml-syringe. Catheters of sizes 16- and 18-gauge were studied in each of 10 patients, and the top-ups were given by senior midwives and anaesthetists. The epidural catheters used were from Portex 'Minisets', with three lateral holes and a 0.2μ flat filter.

A three-way tap was placed between the filter and the syringe which contained the local anaesthetic. A 200-cm manometer line connected this to a 'Dispos-a-Dome' transducer. Pressure signals were recorded directly onto electromagnetic tape for later analysis, but no visual display of the pressure developed was used at the time of injection. Preliminary investigations had revealed that the pressure generated between the syringe and the filter could be in excess of 199.5 kPa. The output of physiological transducers in general use becomes nonlinear if the pressure exceeds 66.5 kPa. A suitable system was built using a Sensym transducer and an analogue Devices isolation amplifier. Linearity and accuracy of this system over the range 0–266 kPa was found to be within ±5%.

Baseline measurements were performed by connecting a pressure gauge between the filter and a 60-ml syringe; the latter was pressurised by hand to the required level and checked against the output of the amplifier. The upper limit of accurate pressure recording of this system was 266 pKa. Pressures higher than this were not of interest because differential flow from the catheter occurred only at pressures of up to 133 pKa.

In vitro study

The flow of local anaesthetic from the holes of a sample of 10 16-gauge and 10 18-gauge epidural catheters was

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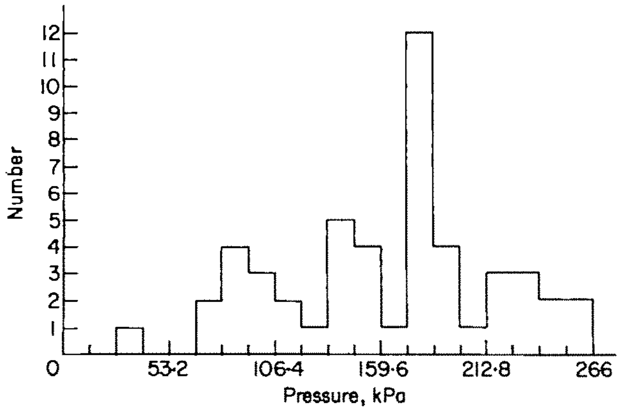

Fig. 1. Frequency histogram of pressures recorded *in vivo* from 16-gauge catheters (50 observations).

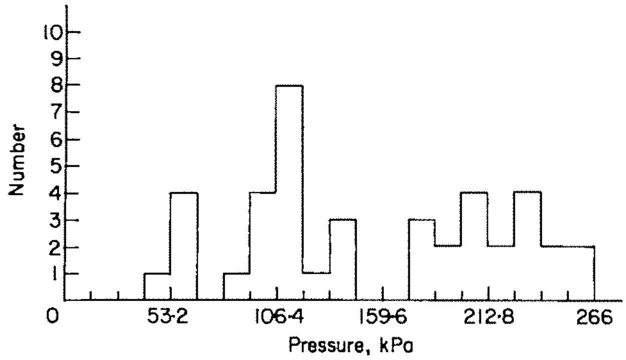

Fig. 2. Frequency histogram of pressures recorded *in vivo* from 18-gauge catheters (41 observations).

Table 1. Summary of pressures recorded from 16- and 18-gauge catheters.

	Pressure, kPa	
Catheter size	Range	Mean
16 gauge	39.9–266	167.2
18 gauge	53.2–266	159

Table 2. Flow observed *in vitro* from the three holes of 10 16-gauge catheters at different pressures.

	Flow from holes		
Pressure kPa	Proximal	Middle	Distal
13.3	+	+	−
26.6	+	+	−
39.9	+ +	+	−
53.2	+ +	+ +	−
66.5	+ +	+ +	−
79.9	+ + +	+ +	+
93.1	+ + +	+ + +	+
106.4	+ + +	+ + +	+ +
119.7	+ + +	+ + +	+ +
133	+ + +	+ + +	+ + +

Rate of flow from each hole indicated: −, nil; +, minimal; + + +, maximal.

Table 3. Flow observed *in vitro* from the three holes of 10 18-gauge catheters at different pressures.

	Flow from holes		
Pressure kPa	Proximal	Middle	Distal
13.3	+	+	−
26.6	+	+	−
39.9	+ +	+	−
53.2	+ + +	+ +	−
66.5	+ + +	+ + +	+
79.9	+ + +	+ + +	+ +
93.1	+ + +	+ + +	+ + +

observed under laboratory conditions. A Bourdon gauge was attached to a three-way tap inserted between a 60-ml syringe and the epidural catheter and filter. Force was applied manually to the syringe barrel to produce pressure readings of 13.3–133 kPa on the gauge. At each pressure the flow of local anaesthetic from the holes on the catheter was observed and recorded as: −, absent; +, minimal; + + +, maximal. It was not possible to make observations beyond 133 kPa because this was the maximum reading on the Bourdon gauge.

Results

In vivo study

In the 16-gauge group 50 pressure recordings were made of epidural doses of 2–10 ml, while in the 18-gauge group 41 pressures were obtained of doses of 2–10 ml. The pressures are shown as frequency histograms in groups of 13.3 kPa in Figs 1 and 2, and the ranges and arithmetic means are shown in Table 1.

In vitro study

A differential flow from the holes did appear when similar pressures were applied to a sample of 10 catheters of each gauge (Tables 2 and 3). Flow was present at the proximal hole at low pressures, and appeared at the middle and distal holes at higher pressures. This pattern was demonstrated in both diameters of catheter. Infrequently flow began at the distal or middle hole in individual catheters, but the general pattern of recruitment of the distal holes with increasing force of injection held for the sample of 10 catheters of each gauge investigated.

Significantly, the pressure range at which differential flow occurs in the laboratory (up to 133 kPa for 16-gauge and up to 93.1 kPa for 18-gauge catheters, Tables 2 and 3) includes values recorded during epidural administration of local anaesthetic during labour (Table 1 and Figs 1 and 2).

Discussion

The first part of this investigation demonstrated the range of pressures used clinically in the administration of doses of local anaesthetic into the epidural space. The second part revealed that at the lower end of this pressure range flow appears first at the proximal, then the middle, and finally at the distal hole of multihole epidural catheters. This evidence supports the hypothesis that the pressure required to inject local anaesthetic during an epidural top-up can produce differential flows from the holes in a multihole epidural catheter. Half of the injections observed in this study were in the range of pressure at which differential flow from the holes could occur. Doses of local anaesthetic administered through a multihole catheter which had been partly passed through the dura could therefore produce epidural or subarachnoid blocks, or a mixed block, depending on the pressure used to inject. *In vivo* the positive pressure in the subarachnoid space would tend to enhance this phenomenon.[3]

A number of anecdotal reports have been published which describe bizarre and often extensive blocks after a top-up injection during the course of a previously normal continuous epidural block. These effects may be because of partial subarachnoid blockade[4,5] or subdural injection.[6,7] Insertion of the catheter into the subarachnoid space may be a possible mechanism and migration of the catheter has also been described.[8,9] Equally important however may be the differential exit distribution of local anaesthetic from multihole catheters which can occur at the differing injection pressures as described in this paper.

The need for careful monitoring of each dose administered through an epidural catheter is clear, as the extent and character of block could change depending on the precise position of the catheter and the pressure of each injection. Indeed it may be that single hole epidural catheters should be preferred to multihole catheters because of the inherent dangers associated with the latter.[5,10]

Acknowledgments

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References

1. Hartley M. The strange case of the inadvertent spinal. *British Journal of Anaesthesia* 1975; **47:** 420.
2. Ward CF, Osborne R, Benumof JL, Saidman LJ. A hazard of double-orifice epidural catheters. *Anesthesiology* 1978; **48:** 362–4.
3. Covino BG, Scott DB. *Handbook of epidural anaesthesia and analgesia.* Copenhagen: Schultz, 1986: 167–8.
4. Kriz M, Jouppila R. Subarachnoid block after a 'top-up' dose during continuous segmental epidural analgesia in labour. A case report. *Acta Anaesthesiolgica Scandinavica* 1980; **24:** 495–6.
5. Maycock E. An epidural anaesthetic with unusual complications. *Anaesthesia and Intensive Care* 1978; **6:** 263–4.
6. Boys JE, Norman PF. Accidental subdural analgesia. A case report, possible clinical implications and relevance to 'massive extradurals'. *British Journal of Anaesthesia* 1975; **47:** 1111–3.
7. Brindle Smith G, Barton FL, Watt JH. Extensive spread of local anaesthetic solution following subdural insertion of an epidural catheter during labour. *Anaesthesia* 1984; **39:** 355–8.
8. Abouleish E, Goldstein M. Migration of an extradural catheter into the subdural space. A case report. *British Journal of Anaesthesia* 1986; **58:** 1194–7.
9. Phillips DC, Macdonald R. Epidural catheter migration during labour. *Anaesthesia* 1987; **42:** 661–3.
10. Beck H, Brassow F, Doehn M, Bause H, Dziadzka A, Schulte am Esch J. Epidural catheters of the multi-orifice type: dangers and complications. *Acta Anaesthesiologica Scandinavica* 1986; **30:** 549–55.

Anaesthesia, 1988, Volume 43, pages 879–883

Forum

An analysis of critical incidents in a teaching department for quality assurance
A survey of mishaps during anaesthesia

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Summary

A prospective survey was conducted from April 1984–January 1985 and April 1985–January 1986 to study the frequency of critical incidents and factors associated with them. Eighty-six mishaps were reported in the first period, the majority of which were because of human error (80.3%);the most common were the transmission of gases and vapours and errors in drug administration. Factors frequently associated with these mishaps were failure to perform a normal check and lack of familiarity with equipment or technique. An anaesthesia equipment checklist was incorporated in the survey during the second period and 43 mishaps were reported. This decrease in incidence may have resulted from the anaesthesia apparatus checklist, awareness of mishaps since they were discussed regularly at departmental meetings, and new anaesthesia machines (eight older machines were replaced during the first period and 11 at the beginning of the second).

Key words

Complications; critical incidents.

Preventable critical incidents occur in all anaesthesia departments despite the best intentions and efforts.[1–6] The need to identify and prevent them has grown partly as a result of the dramatic increase in medical malpractice claims and suits in the United States. Some of these incidents are discussed in departmental conferences and mortality–morbidity rounds; but many go unreported, because of lack of time or on the assumption that everyone is aware of them. No consolidated data and frequency of such incidents are available institutionally or nationally.

Various types of risk-management programme have been suggested but the effect of these on anaesthesia practice is not known.[7,8] This survey was undertaken to enumerate critical incidents and identify factors associated with these, with and without the use of anaesthesia equipment checklists.

Method

Approval for this prospective survey, because of legal implications, was obtained from the Hospital Practice Subcommittee. A critical incident was defined as an incident or mistake which could be harmful or potentially harmful to the patient during management of anaesthesia. All members of the anaesthesia team between April 1984 and January 1985 (Period A) were requested, in the event of a critical incident to submit a written report which described its nature, associated factors, outcome to the patient and recommendations to prevent its recurrence. The collection of information was facilitated by distributing anaesthesia critical incident report forms (Fig. 1) to each member of the anaesthesia team. The report was to be submitted by the member of the team who conducted the anaesthesia and not by a supervisor or observer. All forms were returned to the authors weekly. The reports were anonymous, but all forms were numbered to assess the degree of participation.

In April 1985 (Period B), based upon incident reports collected in period A, an equipment checklist (Fig. 2) was incorporated in the survey. These were placed on each anaesthetic machine in surgical suites before the start of an elective surgical procedure. All anaesthesia providers were asked to follow the equipment checklist in preparation for anaesthesia. The checklist incorporated anaesthetic machines, airway maintenance equipment, suction apparatus, routine drugs and monitors and were collected at the end of scheduled surgical procedures from each operating room and replaced with new ones. The information was gathered until January 1986 as in the previous period. The data retrieved during both periods were updated regularly, were available for inspection by any member of the anaesthesia department and presented at three-monthly intervals in mortality and morbidity rounds of the department.

Results

There were 13 783 and 15 182 anaesthetics administered during the two periods, A and B, respectively by 68 anaesthesia providers during period A, and 74 in period B. The providers were faculty members, anaesthesia residents, interns from other specialties, and senior medical students. Eighty-five percent of the forms distributed were returned during both periods; the equipment checklist was used by approximately 75% of the anaesthesia providers during period B as a part of the preparation for anaesthesia.

There were 86 and 43 critical incidents reported during periods A and B respectively. Sixty-nine (80.3%) of these

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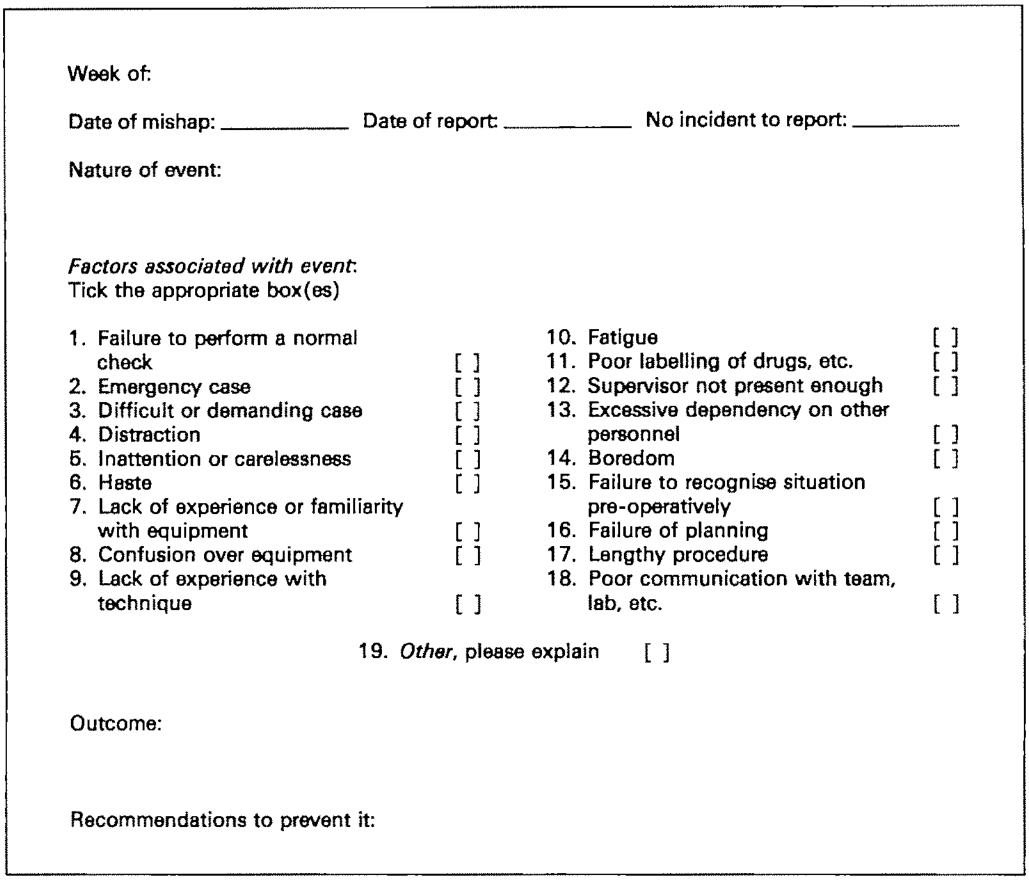


Week of:

Date of mishap: ________ Date of report: ________ No incident to report: ________

Nature of event:

Factors associated with event:
Tick the appropriate box(es)

1. Failure to perform a normal check ☐
2. Emergency case ☐
3. Difficult or demanding case ☐
4. Distraction ☐
5. Inattention or carelessness ☐
6. Haste ☐
7. Lack of experience or familiarity with equipment ☐
8. Confusion over equipment ☐
9. Lack of experience with technique ☐
10. Fatigue ☐
11. Poor labelling of drugs, etc. ☐
12. Supervisor not present enough ☐
13. Excessive dependency on other personnel ☐
14. Boredom ☐
15. Failure to recognise situation pre-operatively ☐
16. Failure of planning ☐
17. Lengthy procedure ☐
18. Poor communication with team, lab, etc. ☐
19. *Other*, please explain ☐

Outcome:

Recommendations to prevent it:

Fig. 1. Anaesthesia critical incident report.

incidents during period A, were as a result of human error while 17 (19.7%) were because of equipment failure. Thirty-five (81.4%) incidents during period B were due to human error and 8 (18.6%) from equipment failure. The critical incidents and factors associated with them are shown in Tables 1 and 2. During period A there were 48 incidents related to a failure in transmission of anaesthetic gases and vapours, 10 from tracheal tubes, 22 due to drug administration and 13 others. In period B there were 17 incidents related to transmission of anaesthetic gases and vapours, one because of tracheal tube, 10 as a result of drug administration and 15 others.

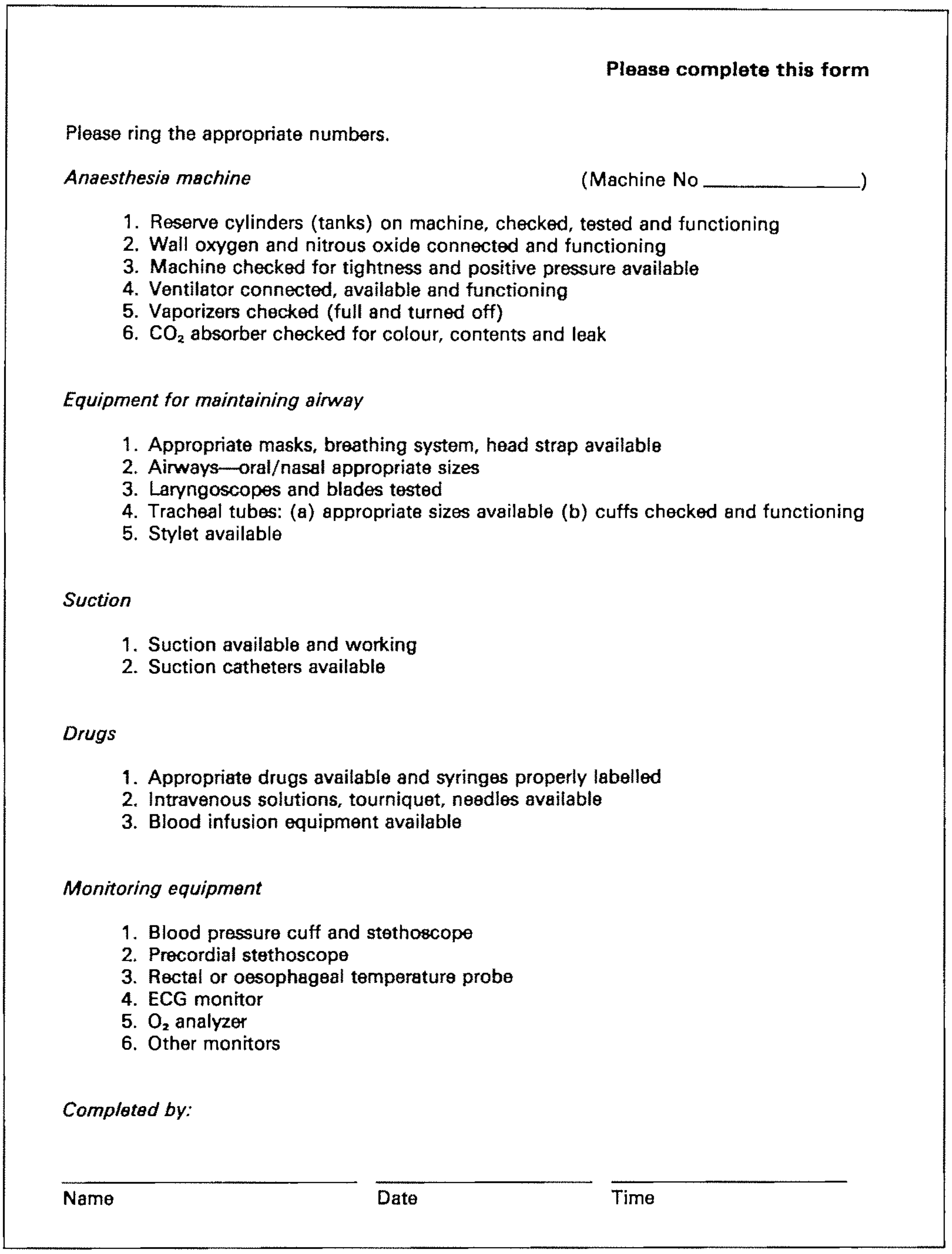
Discussion

The results of this survey agree with those of other similar studies[1,2] that 80% of these critical incidents were caused by human error and 20% by equipment failure. The most common associated factors were failure to perform a normal check of machine and equipment, unfamiliarity or lack of experience with equipment and inattention or carelessness of an individual. Human errors were the major factors during period B, but there was a decrease in the number of incidents. This effect may have followed the provision of the anaesthesia equipment checklist, discussion and awareness of incidents at mortality–morbidity rounds, or the replacement of old anaesthesia machines. Eight old anaesthesia machines were replaced during period A (October 1984) and 11 more were replaced at the beginning of period B (April 1985). Most of the old machines were equipped with Copper Kettle vaporizers which were responsible for the majority of vaporizer problems during period A. The new machines have precalibrated vaporizers besides other built-in safety features.

Many mishaps or incidents as a result of human error and related to anaesthesia equipment can be traced to conditions before induction of anaesthesia. A large number of incidents during period A could have been detected if a thorough pre-induction check was performed. The use of an anaesthesia machine checklist may have contributed to the decrease in the number of incidents during period B. The Emergency Care Research Institute[9] and others[10] have urged anaesthesia providers to use an equipment checklist to reduce the incidence of preventable mishaps, but their application is not very popular and this is substantiated by a recent survey conducted by the Iowa Department of Public Health.[11] Only four of the 45 hospitals surveyed had an equipment checklist although no data existed to verify its use.

Unfamiliarity or lack of experience in the use of anaesthesia machines and equipment was substantiated when we reviewed our didactic teaching programme; only one hour was devoted each year to anaesthesia machines and equipment. However, the basic principles of monitors and equipment were discussed in other didactic courses, but there is no continuing training directed to anaesthesia machines and equipment.

A survey like ours can be surmounted by administrative problems in a department with a large number of individuals who provide anaesthesia services. The major deficiency in our survey is that no correlation was attempted between the checklist and incidents. We were encouraged in spite of this, by the compliance, feedback and suggestions of the participants. The main proposal was to facilitate the avail-



Please complete this form

Please ring the appropriate numbers.

Anaesthesia machine (Machine No ______________)

1. Reserve cylinders (tanks) on machine, checked, tested and functioning
2. Wall oxygen and nitrous oxide connected and functioning
3. Machine checked for tightness and positive pressure available
4. Ventilator connected, available and functioning
5. Vaporizers checked (full and turned off)
6. CO_2 absorber checked for colour, contents and leak

Equipment for maintaining airway

1. Appropriate masks, breathing system, head strap available
2. Airways—oral/nasal appropriate sizes
3. Laryngoscopes and blades tested
4. Tracheal tubes: (a) appropriate sizes available (b) cuffs checked and functioning
5. Stylet available

Suction

1. Suction available and working
2. Suction catheters available

Drugs

1. Appropriate drugs available and syringes properly labelled
2. Intravenous solutions, tourniquet, needles available
3. Blood infusion equipment available

Monitoring equipment

1. Blood pressure cuff and stethoscope
2. Precordial stethoscope
3. Rectal or oesophageal temperature probe
4. ECG monitor
5. O_2 analyzer
6. Other monitors

Completed by:

Name ______________

Date ______________

Time ______________

Fig. 2. Anaesthesia machine equipment checklist.

ability of machine-equipment checklists. Our anaesthetic record consists of a single page and has been used widely for many years; no attempt to modify it to include an anaesthesia machine and equipment checklist has ever been attempted. The checklist, in our opinion, should be a part of the anaesthesia record; this would encourage its use.

The reports of critical incidents were anonymous, nevertheless some under-reporting is probably inevitable. What actually constitutes a reportable incident probably depends on the nature of the incident, how quickly it was detected, the health of the patient and other associated factors. No statistical analysis was performed because of these factors. Our survey enumerated the critical incidents and factors associated with them. These decreased after the provision of checklist, replacement of older anaesthesia machines and awareness of such incidents since they were discussed regularly at departmental meetings. A survey of a similar nature should be undertaken in all anaesthesia departments to assure quality control, identify specific problems and improve training. It is also important to establish nationally or regionally a system to collect data and determine the frequency of anaesthesia related incidents.

Table 1. Summary of critical incidents.

Category	Type of incident	Details of incident	A	B
Transmission of anaesthetic gases and vapours	Vaporizer problems	Copper kettle control error	9	1
		Forgot to turn on vaporizer	2	1
		Fresh gas flow not connected to vaporizer	2	
		Inaccurate calibrations	2	
		Selector valve problems	2	2
		Vaporizer left on accidentally		1
	Disconnexions	Common gas outlet	3	1
		Humidifier	3	
		Fresh gas supply to Bain system	1	
		Pipe gas supply	1	
		Tracheal tube and breathing system		1
	Inadvertent gas flow changes	66% O_2, 33% N_2O	2	
		Accidentally switched off N_2O	1	
		100% N_2O for pre-oxygenation	1	
	Malfunctioning evacuation	Disconnexion at vacuum source	4	1
		Reservoir bag missing		1
	Leaks	Soda lime canister	2	1
		Ventilator bellows	2	
		Humidifier		1
		Broken pressure gauge		1
	Ventilator problems	Paediatric bellows for adult case	1	
		Malfunctioning ventilator	1	3
	Problem with ventilation	Trying to ventilate manually with switch on machine mode	2	1
	Tracheal tube problems	Right main stem intubation	3	
		Obstruction	2	
		Accidental extubation	2	1
		Cuff failure	2	
		Difficult intubation mediastinal emphysema	1	
Drug administration	Syringe swap	Wrong drug given	15	5
		Intravenous infusion swap	1	
	Relative overdosage	Prolonged neuromuscular blockade	4	1
		CNS side effect following axillary block	2	
		Postoperative respiratory depression		1
		1:20 000 adrenaline		1
		Overdose of aminocaproic acid		1
	Other	Ephedrine for normal blood pressure		1
		Hypotension following vancomycin		1
Miscellaneous		Vomiting/aspiration on induction	3	1
		Intravenous disconnexion	2	2
		Significant hypotension after induction	2	
		Epidural catheter without holes	1	
		Subcutaneous lignocaine via epidural catheter	1	
		Patient awakened during surgery	1	
		Exhaustion of soda lime	1	
		Tooth damage	1	2
		Laryngoscope failure	1	
		Intra-operative myocardial infarction		1
		Death six hours after surgery		1
		Significant leak around tracheal tube resulting in ventricular tachycardia		1
		Oxygen sensor failure		1
		Humidifier too hot		1
		Blood warmer malfunction		1
		High spinal		2
		Intravascular placement of epidural catheter		1
		Epidural catheter in subarachnoid space		1
	Total number of incidents		86	43

Table 2. Factors associated with mishaps.

	A	B
Failure to perform a normal check	24	9
Lack of experience of familiarity with equipment	19	7
Inattention or carelessness	19	6
Distraction	12	5
Haste	10	7
Lack of experience with technique	5	3
Difficult or demanding case	3	5
Emergency case	3	3
Fatigue	3	1
Poor labelling of drugs	3	0
Miscellaneous e.g. lengthy procedure, boredom, poor communication, etc.	8	6

References

1. Cooper JB, Newbower RS, Long CD, McPeek B. Preventable anesthesia mishaps: a study of human factors. *Anesthesiology* 1978; **49:** 399–406.
2. Craig J, Wilson ME. A survey of anesthetic misadventures. *Anaesthesia* 1981; **36:** 933–6.
3. Epstein RM. Morbidity and mortality from anesthesia (editorial) *Anesthesiology* 1978; **49:** 388–9.
4. Utting JE, Gray TC, Shelley FC. Human misadventure in anaesthesia. *Canadian Anaesthetists' Society Journal* 1979; **26:** 472–8.
5. Lunn JN, Mushin WW. *Mortality associated with anaesthesia.* London: Nuffield Provincial Hospital Trust, 1982.
6. Deaths during general anesthesia: technology-related, due to human error, or unavoidable? *Technology for Anesthesia ECRI. Plymouth Meeting, Pennsylvania* 1985; **5:** 1–11.
7. Pierce EC Jr. Reducing preventable anesthesia mishaps: A need for greater risk management initiatives. *Risk Management Foundation Forum Cambridge, Mass.* 1985; **6:** 6.
8. Holzer FJ. Current concepts in risk management. Anesthesia mishaps. *International Anesthesiology Clinics* 1984; **22:** 91–166.
9. Emergency Care Research Institute. Avoiding anesthesia mishaps through pre-use checks. *Health Devices* 1982; **11:** 201–3.
10. Carstensen P. FDA issues pre-use checklist. *Anesthesia Patient Safety Foundations* 1986; **1:** 13–20.
11. Kumar V, Hintze MS, Jacobs A. Anesthesia gas delivery systems and ancillary monitors—a survey of Iowa Hospitals. IARS 62nd Congress, 5–9 March 1988, San Diego, California.

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Costs of replacement of anaesthetic equipment.
Projected expenditure for clinical anaesthetic equipment in a teaching health district

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Summary

A study was made of all the anaesthetic equipment in clinical use to substantiate estimates of the cost of its replacement on four hospital sites. The years during which replacement was likely to become necessary were estimated from the list compiled and an existing full inventory, together with costs at 1986 prices. The predicted costs for each year until 2000AD were derived. To these were added sums required to make good existing shortfalls and to introduce a moderate amount of equipment incorporating newer technology. The totals showed that the capital currently available in the health district is sufficient only for anaesthetic equipment and requires a substantial increase to replace medical apparatus belonging to all specialties already in routine clinical use. Health authorities must be given detailed projections of these costs.

Key words

Equipment; costs.

The Area Health Authority in Oxford in 1981 experienced difficulty containing spending on the acquisition and maintenance of clinical equipment; expenditure exceeded the allocated budget by 50%. Equipment users were able to bid for new and replacement items without considering the revenue consequences of subsequent maintenance. A report was commissioned by the clinicians' Medical Staff Council which recommended that all aspects of equipment acquisition and maintenance be considered together. This led to the formation of the Medical Equipment Bank in 1983[1] and since then all equipment bids have been submitted through the Bank.

In Oxfordshire, equipment that costs in excess of £15 000 is funded at regional level, except in the case of regional specialties where the threshold is £7500. No single item attains the £15 000 threshold and none of the work undertaken by the Nuffield Department of Anaesthetics is financed as part of a Regional service, even though a number of the surgical departments for which anaesthesia is provided are recognised regionally-funded specialties. Thus, acquisition of anaesthetic equipment is dependent on district funds. In 1986, the equipment bank asked the equipment manager for anaesthetics to submit a detailed estimate of the costs of replacement and new equipment in

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the foreseeable future. Anaesthetics was selected for this exercise as the largest user of minor capital funded equipment. The results were expected to reinforce the Bank Chairman's submissions for increased funds for replacement items.

Method

A complete inventory of all equipment in anaesthetic care was made when the bank was established.[1,2] It was decided to restrict the projection of replacement costs to items in clinical use and omit those that belonged to the anaesthetic engineering workshops and electronic and physiological laboratories. The main adult intensive therapy unit is included. The author personally surveyed the equipment in the 38 locations where anaesthetics are given together with the main intensive therapy unit. The information was listed for each hospital site with the addition of the purchase date of each item from the earlier full inventory.

The 1986 price (which included value added tax) was obtained for each piece of equipment, in order to predict funds required for an identical or equivalent model. This sum was then divided equally over the range of years during which the equipment was likely to require replacement. An expected life of 10–12 years was allowed for electronic equipment and 12–15 for electromechanical and mechanical devices, following discussions with senior technical staff. These estimates may be too long.[2] An arbitrary 5% was added to the total for each year, on top of replacement costs, to allow for the absence of equipment being serviced and possible oversight in the initial personal survey.

For the purpose of the report to the Equipment Bank, a compound increase of 9% was superimposed on the cost of anaesthetic equipment, which had been estimated at a flat 1986 price, based on a personal survey of the price changes of 15 items of equipment from 1984–6. However, the continuing rate of inflation in equipment prices cannot accurately be inferred from past experience, and the results of the survey are expressed here at 1986 prices. Estimates were also made of the existing shortfall in items of anaesthetic equipment and of the likely requirements for new technology in clinical anaesthesia. The estimate of shortfall was made at two levels. The lower was for equipment required to bring all theatres up to an arbitrary standard thought suitable for the type of surgery performed in them, and was based on knowledge of current standards locally and bids for equipment already placed before the District Medical Equipment Bank. The higher and much larger estimate extended the present standard of the best equipped theatres and anaesthetic rooms to all areas where such a standard is relevant. A further estimate was made of the costs of introducing relatively new technology on a wider scale. The items primarily considered in this group were pulse oximeters, anaesthetic vapour analysers and multiparameter monitors.

Results

The initial survey of anaesthetic equipment in use in clinical areas of the Oxford Hospitals in June 1986 included 752 separate items with a replacement value at 1986 prices including VAT of £1 033 400. Using quotations supplied mainly by Penlon Ltd., Abingdon, Oxford, these included 30 anaesthetic induction machines, both wall mounted and free standing (£51 500), 53 anaesthetic machines for use in operating theatres and in isolated locations (£151 500), 186 assorted vaporizers (£119 000), 60 anaesthetic ventilators (£80 000), mainly Penlon Nuffield 200 series, and 10 intensive therapy unit (ITU) ventilators (£80 000), Siemens 900 series and Penlon Oxfords. The major groups of monitoring equipment comprise 17 ECG-only monitors (£23 500), 25 ECG/pressure/temperature units (£85 000) and seven ITU monitors with two pressure channels (£28 000). This total replacement cost is £617 500. The remainder of the equipment plus an arbitrary 5% for omissions brings it to approximately £1.08 million. The total is £950 000 if blood gas analysers currently maintained by the physiological laboratory are excluded. Just over half the equipment is on the John Radcliffe Hospital site, the primary acute hospital in the District, and 44% of this is in the adult intensive therapy unit.

Very full details of the equipment types, manufacturers, replacement dates and costs were provided in the report submitted to the Equipment Bank executive, as were detailed estimates of costs for each year on each hospital site until 2000AD. As an example, Fig. 1 shows the distribution of replacement costs in three clinical areas: the John Radcliffe acute hospital theatre complex, the John Radcliffe maternity hospital, and the Churchill hospital. The first of these was largely newly equipped for its opening in 1979, while the maternity hospital was re-equipped with all major items for anaesthetics in 1984. Both show a period when replacement needs are likely to be at a maximum. The span of 6 years follows from the estimates of life expectancy for the two groups of equipment, electronic and electromechanical. The replacement of the first group is estimated to start at year 10 while that of the second is expected to be completed by the end of year 15. The equipment on the Churchill hospital site is however of much more varied vintage and some major replacements are overdue and should start now.

Figure 2 shows projected total replacement costs for the hospitals surveyed. The pattern is of moderate expenditure (£70 000 pa) to the end of this decade with a sharp doubling for the next 5–6 years. The tail-off towards the end of the century is to some extent artificial since equipment which should be replaced in the next 3 years has not been taken into account.

Figures 1 and 2 do not include funds necessary to make good the existing shortfall nor make allowance for the introduction of new technology. The major items in the shortfall are oxygen monitors, ventilator failure alarms, ECG monitors for use in the anaesthetic rooms, noninvasive blood pressure monitors, infusion pumps of various types, and end-tidal carbon dioxide analysers. It will cost about £26 000 per annum for 3 years, to provide the minimum increase in numbers considered suitable, while full provision would cost at least £250 000.

The new technology to be considered includes pulse oximeters which already have special indications and may become standard equipment; £50 000 would provide for one unit in each theatre suite plus extra units for use in special areas, while provision of enough oximeters to allow general access would cost up to £250 000. Multivapour analysers would add a further £12 000 for minimal numbers (one per major location) with a possible maximum of £60 000 if ready availability for clinical use is considered desirable. Finally, multiparameter monitors are being marketed which represent a cost saving of about 25% over separate monitors for each parameter. These monitors may be considered when current equipment requires replacement, though separate monitor units have some advantages for servicing.

The total sum required urgently is in excess of £150 000 when the costs of making good shortfalls in equipment to minimum levels and the introduction of small numbers of newer items are amalgamated. A further £450 000 is needed to replace fully shortfalls and introduce a moderate amount of newer technology. Approximately £130 000 per annum at 1986 prices is required for the forseeable future if the

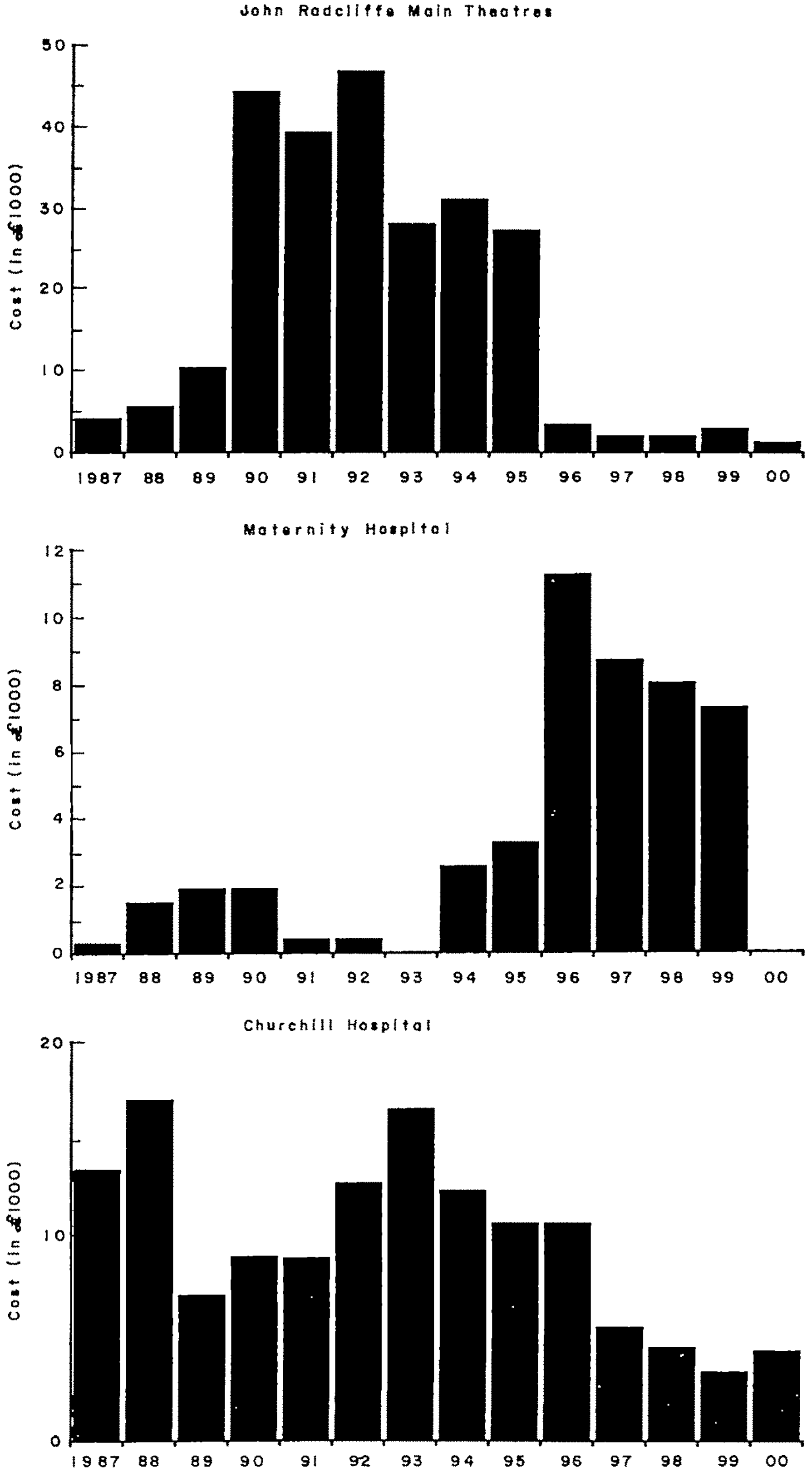

Fig. 1. Examples of distribution of projected replacement costs in three locations.

lowest estimate for making good shortfalls is spread over 3 years and added to the estimates of replacement costs for existing equipment. This is 12% of the capital value of the equipment per annum.[3] Initially only about 8% would be required if no shortfall existed because the majority of equipment on two sites does not require replacement until the next decade. An average of 9–10% of the total capital value of equipment is required for replacement, which relates to its life expectancy with an addition because a small amount has been kept in service beyond those dates.

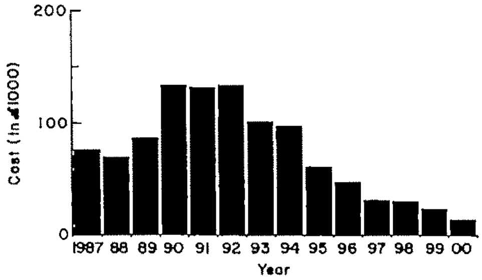

Fig. 2. Distribution of total costs of replacement of existing clinical anaesthetic equipment in central Oxford.

Discussion

Financial constraints have become increasingly important in clinical plans from the beginning of this decade and are the source of some despondency among those responsible for its provision. At the same time the range of instruments is expanding, especially in anaesthesia, orientated towards improving patient safety, while in other clinical areas the pressure may be towards better diagnostic images or more efficient sample handling. Almost all developments require additional funds.[2] In Oxford the remnant of the medical equipment budget after the maintenance costs had been met was £150 000 in 1983 and has decreased to £120 000 in 1986. This is a true fall of one third, allowing for 9% annual inflation in costs, which occurred over this period.

The reduction in available capital is because of the disproportionate increase in maintenance costs compared with the budget for equipment purchase and maintenance. This applies to both in-house and contract maintenance. Equipment purchased by regional funds is maintained from the district budget and most is contract serviced, which utilises an ever increasing proportion of a budget whose growth rate is inadequate to compensate. Had appropriate annual increments been made available to the budget even they would have been meaningless unless the basic level of funding had been assessed correctly at the outset. Recent experience of district funds for anaesthetic equipment suggests that the proportion available for capital purchases is at least 10 times too small; about £10 000 has been allocated in each of the 3 years to 1986.

Bids from all sources which totalled £350 000 were submitted to the Medical Equipment Bank for funding in 1986–7. Only £120 000 was available to meet these, which excluded some routine replacements since many equipment managers deferred these in favour of items requested more urgently.

A current figure of £70 000 per annum for replacement anaesthetic equipment rising to £130 000 by 1990 is a considerable capital expense to a health district, especially as in this case it does not include equipment on a further major site at Banbury. A proportion of this is allocated to the intensive therapy unit and blood gas analysers. If replacement costs for these are excluded and the remainder related to the number of anaesthetics administered, which was 30 000 in 1985, then the current need for equipment replacement would be £1.50 per patient anaesthetised while the cost by the early 1990s will by £2.80 each, not allowing for inflation. Intensive care equipment replacement, estimated at 10% of capital value per annum, will cost £40 for each of the 600 admissions each year. These figures take no account of servicing costs.

As a result of this study, it has been found that about 60% of district minor capital funds are required for replacement of anaesthetic equipment over the next 3 years, and 100% of this capital at the present rate thereafter. The district's entire minor capital allocation to medical equipment is required every year for anaesthetic provision, if existing shortfalls are made good over 3 years at the lowest clinical level. Even this amount would not give significant improvements in standards of anaesthetic equipment beyond those set in 1979 at the opening of the main John Radcliffe hospital. More important, there are 32 other groups whose representatives comprise the Medical Equipment Bank, each with their own requirements for the next decade.

This situation is unlikely to be unique to Oxford. The basic level at which budgets are set for replacement and new equipment needs to be increased enormously. It is, however, necessary for users to offer accurate and complete information to the health authorities to inform them properly of the huge quantity of equipment in use and the inevitable need for its replacement and upgrading.

Postscript

In the latter part of 1986–7 there was increased awareness of the ageing stock in the Oxfordshire District, which resulted in the Regional Health Authority doubling the sum available for its purchase by the District. While the amount allocated for anaesthetic equipment falls a little short of that needed, I like to think that the submission of a detailed prospective study which predicted expenditure on replacement of anaesthetic equipment helped to promote the necessary awareness in the health authorities.

Acknowledgments

The author thanks Ms S. Dyson and Ms T. Bahu for their help in preparing the manuscript and figures.

References

1. Health Equipment Information. No 98. January 1982. DHSS.
2. Elliot A. Hidden costs of high technology. *Health and Social Service Journal.* 1986; **96:** 82.
3. Yanish DL. Equipment spending will rise 13.6%; most will go for replacement items. *Modern Healthcare.* 1979; **9:** 16.

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Hypersensitivity reactions to alfentanil?

A thirteen-year-old, 42-kg girl with congenital cloacal abnormalities presented for elective vaginoplasty. She had insulin-dependent diabetes and a past history of mild asthma which had not required any specific therapy. There was no history of drug allergy or any problem related to a large number of previous anaesthetics.

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Letters must be typewritten on one side of the paper only and double spaced with wide margins. Copy should be prepared in the usual style and format of the Correspondence section. Authors must follow the advice about references and other matters contained in the Notice to Contributors to *Anaesthesia* printed at the back of each issue. The degrees and diplomas of each author must be given in a covering letter personally signed by all the authors.

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Anaesthesia was induced with atropine 0.1 mg, alfentanil 0.2 mg and thiopentone 200 mg after premedication with diazepam 8 mg. The trachea was intubated following vecuronium 4 mg; intermittent positive pressure ventilation of the lungs was started and anaesthesia maintained with isoflurane in oxygen and nitrous oxide. She was monitored throughout with precordial stethoscope, noninvasive arterial pressure monitor and electrocardiograph. There was no detectable bronchospasm after intubation. A caudal epidural block was then performed with 8 ml of bupivacaine 0.5% to provide intra-operative and postoperative analgesia. Twenty minutes later, before surgical stimulation, a further increment of alfentanil 0.2 mg was administered but there was no increase in heart rate in response to incision. Severe life-threatening bronchospasm developed within minutes with central cyanosis and great difficulty was encountered in the maintenance of any lung inflation. The surgeon commented at the same time that large weals were appearing on the perineum and on removal of the drapes this reaction was seen to be widespread. The urticarial weals were seen particularly on the arms, neck and lateral aspects of the chest and abdomen where they formed an almost confluent cobblestone appearance. Arterial pressure remained satisfactory but there was a marked increase in heart rate to 145 beats/minute.

The episode was treated with oxygen 100% by manual ventilation, aminophylline 125 mg, chlorpheniramine 5 mg and hydrocortisone 100 mg intravenously. The patient's colour improved and the bronchospasm gradually eased over the next 10 minutes sufficient to allow surgery to start uneventfully. Further increments of vecuronium were administered without complication during the procedure and myoneural blockade reversed cautiously 40 minutes later with atropine and neostigmine. Nebulised salbutamol was administered after extubation and within 3 hours the bronchospasm and skin rash had resolved completely.

Blood samples taken for immunological investigation, between 30 minutes and 24 hours, were referred to the Supraregional protein reference unit in Sheffield and showed the reaction to be nonspecific and histaminoid in nature. Plasma IgE levels were 10 times normal at 400–500 U/ml with clinically significant levels of antibodies to both horse and dog dander, which indicated an allergic tendency. Circumstantial evidence would appear to implicate alfentanil as the offending agent, particularly with regard to the temporal relationship between administration and reaction. It is difficult however to explain why this should not have occurred within the first administration unless the reaction was modified by agents given subsequently. Anaphylactoid reactions in response to surgical stimulation have been known to occur[1] but this would be unlikely with an effective epidural block. Bupivacaine could also possibly be implicated although hypersensitivity reactions are very rare[2] and in a recent review no reactions to epidural administration were reported.[3] In addition, she gave a history of previous uneventful dental procedures carried out under local anaesthesia. There was no reaction to subsequent administration of vecuronium or atropine and the patient has since had a similar skin preparation applied without incident. There was no evidence of an immune mechanism in our initial assessment so it was decided not to proceed with *in vivo* assessment by intradermal testing which, in any case, has little value in the assessment of local anaesthetic reactions[4] and has a significant incidence of false positive reactions with myoneural blocking agents.[1] There are to our knowledge no reports of hypersensitivity reactions associated with alfentanil and few significant adverse reactions.[5] We present no conclusive evidence that alfentanil was the offending agent, but this case illustrates that even immunologically safe agents cannot be entirely free from causing an anaphylactoid response in all patients.

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References

1. Watkins J. Investigation of allergic and hypersensitivity reactions to anaesthetic agents. *British Journal of Anaesthesia* 1987; **59**: 104–11.
2. Brown DT, Beamish D, Wildsmith JAW. Allergic reaction to an amide local anaesthetic. *British Journal of Anaesthesia* 1981; **53**: 435–7.
3. Reynolds F. Adverse effects of local anaesthetics. *British Journal of Anaesthesia* 1987; **59**: 78–95.
4. Fisher M McD. Intradermal testing in the diagnosis of acute anaphylaxis during anaesthesia—results of five years experience. *Anaesthesia and Intensive Care* 1979; **7**: 58–61.
5. Dechene JP. Alfentanil as an adjunct to thiopentone and nitrous oxide in short surgical procedures. *Canadian Anaesthetists' Society Journal* 1985; **32**: 346–50.

Otic barotrauma due to nitrous oxide

The debate as to whether or not to use nitrous oxide as the carrier gas in general anaesthesia continues.[1,2] Amongst the factors to be considered are the changes in middle ear pressure which occur both intra- and postoperatively.[3] We report a case of acute otic barotrauma associated with nitrous oxide anaesthesia.

A 50-year-old woman who weighed 65 kg presented for vaginal hysterectomy. She had a mild upper respiratory tract infection (URTI) 10 days previously but was asymptomatic on admission. She had suffered as a child from bilateral ear abscesses but had no ear trouble for the past 20 years. There was nothing else of note in her past medical history other than unspecified treatment for hypertension.

She was premedicated with papaveretum 15 mg and hyoscine 0.3 mg one hour before operation. Anaesthesia was induced with fentanyl 100 μg, thiopentone 350 mg and vecuronium 7 mg. Her lungs were ventilated with 67% nitrous oxide, 33% oxygen and 1% enflurane after tracheal intubation. A caudal epidural was performed for per- and postoperative analgesia. Anaesthesia and initial recovery were uneventful. The patient complained of persistent deafness after operation which she claimed was present from the time she awoke from the anaesthetic. She was referred for an opinion, to a senior consultant otorhinolaryngologist who found bilateral decrease in hearing acuity with conductive loss in both middle ears. Direct examination revealed possible bilateral perforation of the tympanic membranes (TMs) with blood in both middle ears. Both TMs showed old scarring. These changes were consistent with acute otic barotrauma related to anaesthesia. No specific treatment was indicated. ENT review 10 days later showed bilateral hearing loss on audiometry, apparently healed TMs and blood still in both ears. The patient's hearing is improving and she is still under review.

Nitrous oxide has been shown to cause marked changes in middle ear pressure (MEP) both intra- and postoperatively. Nitrous oxide is more soluble than nitrogen in blood and there is a net influx of gas molecules into the middle ear. This results from the significantly higher diffusion rate of the inspired gas along its concentration gradient into the cavity of the middle ear when compared to the diffusion rate of nitrogen out of the cavity into the blood. The middle ear cavity is a noncompliant space, and if the Eustachian tubes are blocked there will be an increase in pressure until the equilibrium point is reached when the gas concentrations within the cavity and the blood are identical. Nitrous oxide is 30 times more soluble in blood than nitrogen and it has been shown that a rapid increase in MEP to over 2 kPa can occur within 5 minutes of exposure to nitrous oxide.[4]

Passive intra-operative or active postoperative venting of the middle ear occurs *via* the Eustachian tubes in most fit individuals which tends to minimise these pressure changes. However, in those patients with compromised middle ear or Eustachian tube function caused by acute or chronic infections or nasopharyngeal inflammation this may not occur. This patient has a history both of previous ear disease and a recent URTI. Therefore she probably had some degree of Eustachian tube dysfunction leading to large changes in MEP in the pre-operative period with consequent otic barotrauma. Owens *et al.* have recommended the avoidance of nitrous oxide in susceptible individuals.[5]

There are safe and reliable techniques of total intravenous anaesthesia available while the lungs are ventilated with air enriched with 40% oxygen. It is now our practice to take an otological history and perform direct visualisation of the tympanic membranes in many patients. Anaesthesia can be maintained by a total intravenous technique and the patient spontaneously breathes, or is ventilated with, oxygen-enriched air.

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References

1. Coe AJ. Nitrous oxide and hearing loss. *Anaesthesia* 1987; **42:** 1230–1.
2. Burns THS. Nitrous oxide and hearing loss. *Anaesthesia* 1988; **43:** 426.
3. Davis I, Moore JRM, Lahiri SK. Nitrous oxide and the middle ear. *Anaesthesia* 1979; **34:** 147–51.
3. Mann MS, Woodsford PV, Jones RM. Anaesthetic carrier gases. Their effect on middle-ear pressure peri-operatively. *Anaesthesia* 1985; **40:** 8–11.
5. Owens WD, Gustave F, Scarloff A. Tympanic membrane rupture with nitrous oxide anesthesia. *Anaesthesia and Analgisia* 1978; **57:** 283–6.

Headache after general anaesthesia

Nausea and vomiting after anaesthesia is rightly regarded as an unpleasant inconvenience to the patient, and may even be a more disagreeable side effect than the pain associated with the surgical procedure. It therefore attracts considerable research attention. However, I feel that the headache that may follow general anaesthesia is a much neglected form of morbidity. There are few data that relate to the incidence of headache after anaesthesia, but anecdotal evidence suggests that it is not uncommon. Two hundred consecutive patients from a weekly gynaecological surgical list were therefore surveyed in order to assess the frequency and severity of headache.

The patients were interviewed 24 hours after surgery and were, in addition, given a brief questionnaire to return at the end of the first week after operation. Thirty-six patients were lost completely to the survey because they were discharged before the interview; a further 22 failed to return the questionnaire. However, some interesting results did emerge. Thirty-eight percent of the patients (63 out of 164) had headaches in the first 24 hours; eight of these described their headaches as severe. A further 10% developed headaches between 24 hours and 7 days after operation. Thus approximately 48% of patients experienced headaches within the first week.

No effort was made to standardise anaesthesia for these patients, and a variety of techniques were used. Some epidural and caudal blocks were performed, with light general anaesthetic cover, but there were no dural taps, and no cases were carried out under regional anaesthesia alone. The numbers for any given technique were too small for statistical analysis. However, those patients who were premedicated with papaveretum and hyoscine, induced with thiopentone, whose lungs were ventilated with nitrous oxide, oxygen and enflurane after neuromuscular paralysis with atracurium, had a substantially lower incidence of headache (15% in the first 24 hours) than those anaesthetised by other methods. Patients had a higher incidence of headache in the first 24 hours (50%) after minor procedures than after intermediate procedures (37%) or major surgery (23%). Patients were asked whether they considered themselves to be 'subject to headaches'; 47 patients did, and 22 of these (47%) had headaches in the first 24 hours.

The figures obtained are much at variance with those from Cohen *et al.*[1] who quote an incidence of headache of about 0.4%. However, they excluded day and short stay cases, and symptoms were only recorded if voluntarily offered by the patient. There are many possible explanations for the findings. Patients, for instance after minor procedures, may be more alert, and aware of minor discomforts, such as headache. Headaches in patients after major surgery may be masked by narcotic analgesics administered for pain of surgical origin. Fasting before operation has a part to play, and this may be at least as relevant as the nature of the anaesthetic itself. The data must also be considered against the normal incidence of headaches in the adult female population as a whole, and I have found no data for this background level.

This brief and imperfect survey raises more questions than it answers; however, it seems that the problem of postoperative headache merits more attention than is currently bestowed upon it.

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Reference

1. Cohen MM, Duncan PG, Pope WDB, Wolkenstein C. A survey of 112 000 anaesthetics at one teaching hospital (1975–83) *Canadian Anaesthetists' Society Journal* 1986; **33:** 22–31.

Subarachnoid anaesthesia for Caesarean section

We read with interest the report by A.R. Michie *et al.* (*Anaesthesia* 1988; **43:** 96–9). Subarachnoid anaesthesia has been used recently in our hospital for Caesarean sections with very satisfactory results. Our practice differs from that of the authors in several respects. We preload our patients with 500 ml compound sodium lactate solution and 500 ml modified gelatin (Gelofusine) before the subarachnoid block is established. Intramuscular ephedrine 30 mg is given prophylactically 15–30 minutes before the spinal block. The patient is placed in the left lateral position and 1.5–2.0 ml 0.5% heavy bupivacaine are injected at L_{2-3} or L_{3-4} interspace through a 26-G spinal needle, using minimal barbotage.

The patient is placed supine immediately with right lateral tilt and the extent of the block assessed with ethyl chloride spray. The table is then tilted to obtain a block to T_6 and the table returned to a left lateral tilt when surgery starts.

This technique has been used on 40 patients with satisfactory analgesia in all cases. Hypotension (systolic 100 mmHg or symptomatic) in 23% of patients was rapidly corrected with intravenous increments of ephedrine; in two patients the hypotension was serious. Postoperative headache was minimised by taking great care to ensure that there was only a single puncture of the dura and keeping the patients flat for 12 hours after the Caesarean section.

We consider subarachnoid anaesthesia to have significant advantages over epidural anaesthesia for Caesarean section, in particular because of the rapid onset of action and the more profound analgesia produced. These qualities are of particular value for emergency Caesarean sections. We agree with the authors, however, that its main disadvantage is in the variable and short duration of action of 0.5% heavy bupivacaine. It is not used if operative difficulties are envisaged.

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A reply

Thank you for the opportunity to reply. We are pleased that the authors have successfully used subarachnoid anaesthesia for Caesarean sections. We continue to give crystalloid alone for preload, but in addition we add 30 mg ephedrine to the third 500-ml bag of Ringer-lactate solution. This is started immediately after subarachnoid injection, in anticipation of hypotension rather than in response to it. We consider that using intramuscular ephedrine, as the authors suggest, may be inappropriate if there is difficulty or protracted delay in establishing blockade.

It is also pertinent to point out that in the most recent Data sheet for Gelofusine (1988), it is stated: 'Anaphylactoid reactions are exceedingly rare, but may be likely to occur if Gelofusine solution is given rapidly to normovolaemic patients, in common with other plasma substitutes. It should not be used to prevent falls in arterial pressure, consequent on spinal or epidural analgesia'.

The authors' efforts to reduce the incidence of headache are admirable, but in practice it is not always possible to guarantee a *single* dural puncture in every case, especially with obese or oedematous patients. There is also great resistance from some nursing mothers, at the requirement to lie flat, even for 12 hours postoperatively. Allowing these women to sit up and feed their infants, should not substantially alter the incidence of headache. We agree in general terms however, that subarachnoid anaesthesia will only be satisfactory in Caesarean section if meticulous attention is paid to avoidance of the major side effects of hypotension and postural headache.

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Hyperkalaemia and cardiac arrest after the use of suxamethonium in intensive care

We wish to report a rapid increase in the serum potassium which led to cardiac arrest after injection of suxamethonium for the change of a tracheal tube in a septic patient.

The patient was a previously fit 66-year-old man admitted for interval cholecystectomy after repeated attacks of cholecystitis; surgery was delayed by the patient's initial refusal of an operation. The gall bladder and surrounding tissues were found to be inflamed and oedematous; this caused haemorrhage from the right hepatic vein. Haemostasis proved difficult and required three operations on consecutive days, after which he was admitted to intensive care for ventilation of his lungs and parenteral nutrition.

His postoperative course was complicated by clotting abnormalities, renal impairment, sepsis and increasing jaundice caused by biliary obstruction. Twelve days after his initial operation he underwent further surgery for biliary drainage. He required a change of oral to nasal tracheal tube to facilitate weaning on the 17th day after the first operation. His renal function at this time was normal (serum creatinine 40 mmol/litre), and serum potassium was 4.2 mmol/litre one hour before the tube change. He was anaesthetised with etomidate 10 mg and suxamethonium 100 mg without precurarisation. Ventricular tachycardia developed with a decrease in arterial blood pressure from 160/90 to 90/60 mmHg immediately after the passage of the nasal tube into the pharynx. His trachea intubated orally and his lungs ventilated with 100% O_2 but he became pulseless and external cardiac massage was started. DC cardioversion with 100, 200 and 300 joules failed to change the ventricular tachycardia; lignocaine 100 mg followed by further cardioversion, and disopyramide 20 mg was similarly unsuccessful. Arterial blood was taken from the arterial line for serum potassium 5 minutes after cardiac arrest. Twenty-five millilitres of 50% dextrose with 10 units soluble insulin were then administered with spontaneous reversion to sinus rhythm. The potassium was 9.9 mmol/litre (checked twice, Technicon RA1000), and bicarbonate was 24 mmol/litre.

Serial ECGs, and assays of aspartate aminotransferase, creatinine phosphokinase did not demonstrate changes of myocardial infarction. The tracheal tube was changed uneventfully later the same day under propofol and atracurium anaesthesia. The patient made a full recovery after a prolonged hospital stay.

Suxamethonium is known to cause an increase in serum potassium after burns, paraplegia in denervation syndromes, renal failure and infections, but a rise of 5.4 mmol/litre sufficient to cause cardiac arrest has not been reported before in a patient in intensive care. Khan[1] recorded a maximum increase in serum potassium in severely septic patients of 2.3 mmol/litre (mean 1.7 mmol/litre) and commented that the rise was greatest in patients confined to bed for 8–21 days, which corresponds to the 17 days in our patient. Kohlschutter[2] reported increases in potassium of 2.5 to 3.1 mmol/litre in four patients who had sepsis for at least 2 weeks but these patients received pancuronium 2 mg before suxamethonium which may have reduced the rise of serum potassium;[3] none of these four suffered cardiac arrest, although one other infected patient did after suxamethonium, but the serum potassium was not measured.

The patient we have reported was infected on the evidence of a pyrexia, leucocytosis (17.2 × 10^3/cu mm) and C-reactive protein 177 mg/litre, together with a coagulase-negative *staphylococcus* cultured from the subhepatic space and abdominal drain sites, but he had none of the other conditions associated with hyperkalaemia in response to suxamethonium.

We recommend that suxamethonium be not used in severely infected patients in intensive care despite the advantage of rapid onset and short action, since other, safer short acting competitive muscle relaxants are available.

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References

1. Khan TZ, Khan RM. Changes in serum potassium following succinylcholine in patients with infections. *Anesthesia and Analgesia* 1983; **62:** 327–31.
2. Kohlschutter B, Baur H, Roth F. Suxamethonium-induced hyperkalaemia in patients with severe intra-abdominal infections. *British Journal of Anaesthesia* 1976; **48:** 557–61.
3. Weintraub HD, Heisterkamp DV, Cooperman LH. Changes in plasma potassium concentration after depolarizing blockers in anaesthetized man. *British Journal of Anaesthesia* 1969; **41:** 1048–52.

Another problem with an expiratory valve

We report a potentially serious incident which occurred recently in our Neurosurgical Intensive Care Unit.

A 52-year-old man was admitted after a road traffic accident who required mechanical ventilation of his lungs. A Servo 900C ventilator was brought from the storage area. The patient was connected to the system after satisfactory inspection of the breathing system and mechanical ventilation started. The expiratory airway pressure exceeded 1 kPa within a few breaths despite no positive end expiratory pressure (PEEP) being set. The patient was disconnected immediately and ventilated with an AMBU bag until another functioning ventilator was available.

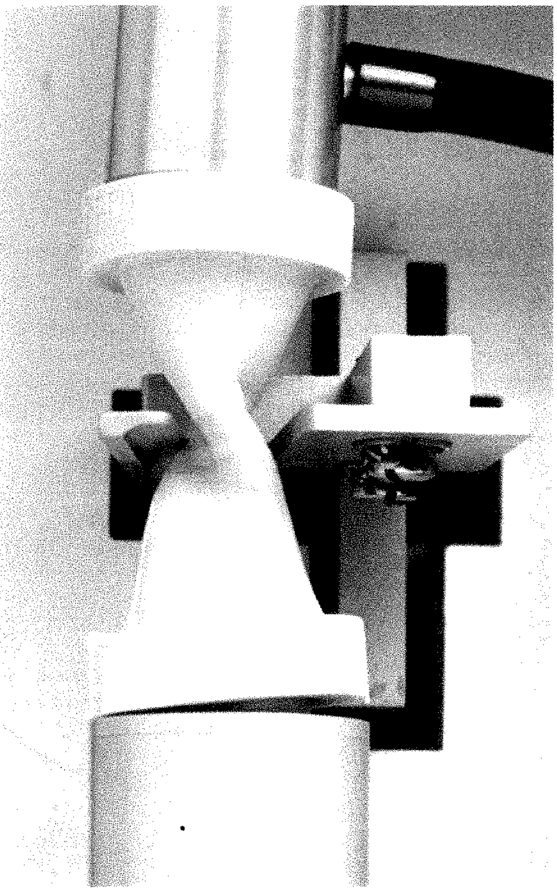

Fig. 1. Close-up overhead view of the twisted assembly.

Internal inspection of the pneumatic module of the ventilator showed the expiratory valve to be twisted in its long axis, almost occluding the lumen (Fig. 1). We thought at first that the incident was related to misassembly of the valve itself, however we were assured by the technician that this was not the case.

The incident was reported to Siemens and after investigation, the following explanation was offered (personal communication).

Immediately upstream of the expiratory valve is a T-piece which connects the expiratory limb of the system to the expiratory pressure transducer. This is normally assembled with the side limb pointing almost horizontally. A fine plastic tube runs from the side limb of the T, passes below the connexion for the expiratory flow transducer and finally joins with the pressure transducer (Fig. 2). The tube that joins the T to the pressure transducer assumes a tight S-shape if the T-piece is assembled with the side arm pointing vertically downwards. This configuration causes a rotational force which tends to pull the side limb of the T towards its normal horizontal position. The expiratory valve immediately downstream of this is also subjected to this rotational force, and since the distal end of the valve is firmly anchored to the ventilator casing, the valve becomes twisted and may cause obstruction of the lumen. The maintenance manual illustrates the short limb of the T-piece assembled horizontally rather than vertically downwards but explicit instructions are not given in the text.

Excessive airways pressure occurs when the flow of expiratory gas is impeded or obstructed. The effects of excessive airways pressure vary according to the manner in which the pressure is applied. If PEEP is low and slow in onset little disturbance may occur[1] but with a rapid increase of pressure to a high level, pneumothorax, pneumomediastinum, pneumoperitoneum,[2] and circulatory collapse,[3] are more likely to develop. Raised end expiratory pressure may cause increases in intracranial pressure; this could prove disadvantageous to an already precarious cerebral circulation.[4] Fortunately our patient suffered no ill effects.

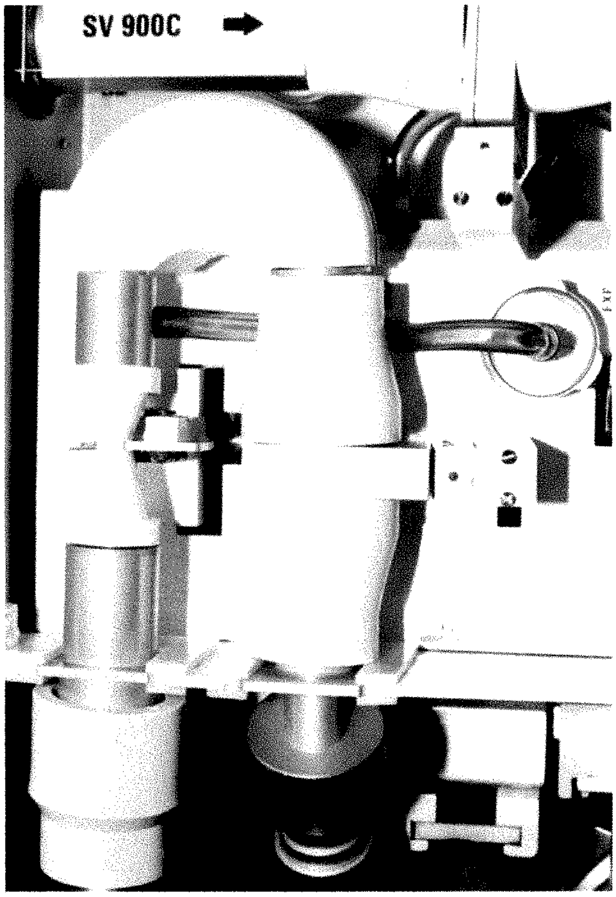

Fig. 2. Overhead view of the normal assembly.

It is probable that the ventilator in question passed its initial test period after assembly, and the twisting of the valve may have taken some time to develop completely. This type of incident could be avoided by running the ventilator for a short period while connected to an artificial lung or reservoir bag before connexion to a patient.

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References

1. HENZIG D. Insidious PEEP from a defective ventilator gas evacuation outlet valve. *Anesthesiology*. 1982; **57:** 251–2.
2. SEARS B, BOCAR N. Pneumothorax resulting from a closed anesthesia ventilator port. *Anesthesiology*. 1977; **47:** 311–3.
3. ROTH S, TWEEDIE E, SOMMER RM. Excessive airway pressure due to a malfunctioning anesthetic ventilator. *Anesthesiology*. 1986; **65:** 532–4.
4. MARSH ML, MARSHALL LF, SHAPIRO HM. Neurosurgical intensive care. *Anesthesiology*. 1977; **47:** 149–63.

A reply

The event described by Dr Murray was also the subject of a communication between the Department of Health, the Central Services Agency, Scotland and Siemens, July 1987, at which time Siemens attempted to reproduce such an event and failed to do so.

The T-piece connector described in Dr Murray's article is connected at one end to the expiratory valve; the other end is held firmly in a silicone rubber block. We are not convinced that sufficient force is developed, such as would be required to turn the T-connector within this block and thus twist the expiratory valve, as depicted.

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A hazard associated with removal of carbon dioxide cylinders

We would like to report a serious hazard associated with the recently recommended practice (Safety Committee of the Association of Anaesthetists of Great Britain and Ireland) of removal of carbon dioxide from anaesthetic machines.

A patient was connected to a circle system supplied by gas from a Boyle M (Ohmeda) anaesthetic machine. The initial flow rates measured at the Rotameters were 4 litres/minute nitrous oxide and 2 litres/minute oxygen, but soon after entering theatre the inspired oxygen concentration ($F\text{IO}_2$) was noted to be not 0.33 but 0.11 and the patient became cyanosed. The patient's lungs were immediately ventilated with 100% oxygen, and the cyanosis disappeared; maintenance of anaesthesia was continued with 50% oxygen, nitrous oxide and isoflurane. The patient's clinical condition, tracheal tube, breathing system and anaesthetic machine were all checked but no fault was found at first. The patient recovered with no untoward sequelae, and only after further checks on the anaesthetic machine was the cause found. The carbon dioxide needle valve was wide open and required at least 15 turns to close it, whereupon the measured $F\text{IO}_2$ returned to 0.33. The carbon dioxide bobbin had at all times been at the bottom of the Rotameter, since the carbon dioxide cylinder had been removed from the machine. The oxygen concentration was measured at the inlet of the carbon dioxide cylinder yoke with a flow of 4 litres/minute nitrous oxide and 2 litres/minute oxygen set on the Rotameters, and a high concentration of oxygen was found, which confirmed the leak. Routine pre-anaesthetic checks of oxygen and nitrous oxide that included bobbin bounce had not detected the leak and further checks after the incident confirmed this.

A similar problem has been reported with cyclopropane,[1] where the cause was leakage that occurred retrogradely through the Rotameter valve when the cyclopropane-dedicated pipework was not pressurised by a cylinder or yoke plug. Recommendations were made after this incident for a routine check that the cyclopropane Rotameter needle valve was closed and that yoke plugs be fitted when cylinders were removed.[2] The International Standard on anaesthetic machines already required that 'unidirectional valves shall be provided which prevent reverse flow of gases from the apparatus to the pipelines or atmosphere'. Rotameter valves are not unfortunately always checked, yoke plugs are frequently not available and the unidirectional valves fitted to carbon dioxide regulators are not spring-loaded and are only effective at high pressures.

The recommendation to remove carbon dioxide cylinders from anaesthetic machines when not in use has not met with universal agreement. In view of this report it would seem that this may be a dangerous practice, that carries the risk of hypoxia, which is surely worse than that of hypercarbia. The use of a yoke plug is a possible remedy but frequent change of cylinders for yoke plugs is more likely to cause problems than a simple check that the carbon dioxide cylinder is turned off when not in use, and that the carbon dioxide and cyclopropane needle valves are also off and the bobbins at rest at the start of every case.

Removal of cylinders has certainly been effective in highlighting the problems associated with carbon dioxide, but perhaps the Safety Committee should now reconsider the advisability of its recommendation.

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References

1. Bishop C. Levick CH. Hodgson C. A design fault in the Boyle apparatus. *British Journal of Anaesthesia* 1967; **39:** 908.
2. Williams AR, Hilton PJ. Selective oxygen leak. A potential cause of patient hypoxia. *Anaesthesia* 1986; **41:** 1133–4.

Use your Brain!

We have recently evaluated the first production model of the size 3 Brain Laryngeal Mask[1] (BLM). A number of consultants and junior staff have used the BLM in a variety of general anaesthetics for surgery which includes ophthalmic ENT, orthopaedic and major abdominal procedures. We are in the process of a formal study of the BLM in this District but consider that a preliminary letter is indicated.

We have used the BLM in over 150 cases in the last 2 months. Blind insertion after a propofol induction without use of muscle relaxants, laryngoscope or introducer is rapid and successful at the first attempt in the majority of cases. All grades of anaesthetist achieved good results after brief instruction and observation of a single insertion. Initial placement is associated with either an obviously clear airway or occasionally an obviously obstructed airway. An airway can be readily achieved by one or more of the following simple manoeuvres, partial removal and re-insertion, removal and re-insertion after neck flexion, anterior traction of the glottis, confirmation of the correct shape of the evacuated BLM cuff before insertion, or, finally the use of the introducer. The BLM required to be placed with a laryngoscope twice, which negates one of its great advantages, avoidance of the noxious stimulus of laryngoscopy.[2]

The correct position of the BLM is verified by bag and chest movement in the spontaneously breathing patient. Squeezing the bag indicates the degree of airway seal achieved. Listening and feeling for leaks, measurement of inflation pressure and correlation with chest movement and expired tidal volume indicates the effectiveness of controlled ventilation. Measurement of end-tidal CO_2 and oxygen saturation are useful adjuncts where available. An audible leak often occurs after insertion; this usually ceases spontaneously after 3 or 4 minutes. Larger leaks occasionally require some manipulation of the BLM but in no case has replacement by a tracheal tube proved necessary.

The advantages of the BLM over conventional facemasks are soon apparent in the spontaneously breathing patient: an excellent secure airway is obtained rapidly, without the need to hold the mask or chin, or for a harness and tracheal intubation is avoided. Since, in contrast to the tracheal tube, the vocal cords and trachea are untouched by the BLM, which sits just above the laryngeal inlet, the need for muscle relaxants and (or) deep anaesthesia is avoided.

The smoothness of the cardiovascular responses to BLM insertion seem to contrast markedly with the oft observed instability on tracheal intubation. Similarly, during emergence, the BLM is tolerated for much longer than is a tracheal tube. We allow patients to awake with the inflated

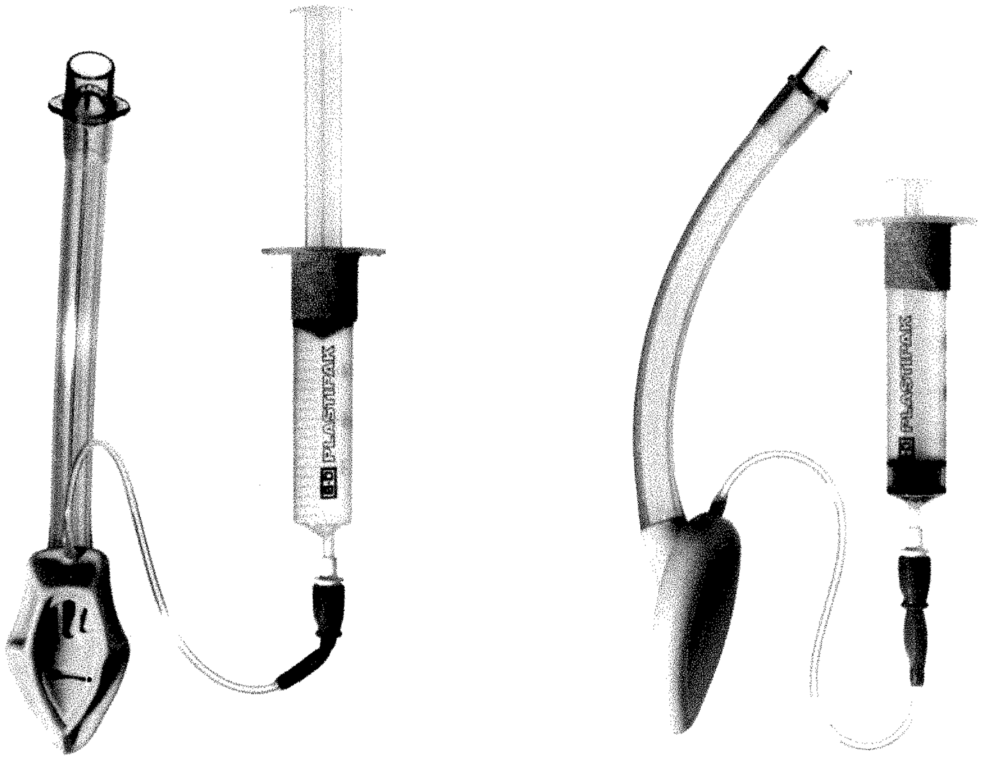

Fig. 1. The first production model of the size 3 Brain Laryngeal Mask. Left, shape deflated for insertion; right, with cuff inflated.

BLM in place at which point it is deflated and removed with minimal disturbance of the patient. We use an oral airway at the same time to prevent biting of the BLM.

The BLM was used successfully on five occasions for patients known to be very difficult to intubate. One of these was a patient with ankylosing spondylitis and a severe cervical spine fixed flexion deformity; insertion of the BLM was without difficulty and recovery was uneventful. An extremely obese patient of 153 kg with angina and a hiatus hernia, who was anticipated to be very difficult to intubate, was managed with the BLM and controlled ventilation for a minor procedure. This use in patients with ischaemic heart disease appears to be a significant advance.

A further possible role is in cardiopulmonary resuscitation in certain circumstances, and in this context we have found that nonanaesthetic medical colleagues, operating department assistants and ambulance staff, can, after appropriate instruction, position the BLM successfully. The production model is designed to be autoclaved repeatedly and a number of ours have survived over 40 anaesthetics and subsequent autoclavings without damage, which indicates economic viability at its current price.

The BLM should be considered whenever the indication for tracheal intubation does not include protection of the airway from gastric contents. It is not recommended in its present form for use in the emergencies when the likelihood of regurgitation is present.

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References

1. BRAIN AIJ. The laryngeal mask—a new concept in airway management. *British Journal of Anaesthesia* 1983; **55:** 801–4.
2. FOX EJ, SKLAR GS, HILL CH, VILLANUEVA R, KING BD. Complications related to the pressor response to endotracheal intubation. *Anesthesiology* 1977; **47:** 524.

Paradoxical thrombo-embolism

We read with interest the case report by Coleman and Wilson-MacDonald (*Anaesthesia* 1988; **43:** 213–5) about a fatal paradoxical thrombo-embolism. We have recently had a similar case and believe there is a further important point which was not raised in their discussion.

A 57-year-old male fell from a ladder and sustained an occipital skull fracture and fracture of the right tibia and fibula. A computerised tomographic scan revealed superficial contusion of the frontal lobes, however, clinically there was no neurological deficit, other than mild irritability. Open reduction and plating of the tibial fracture was proposed, but postponed in view of the risk of anaesthesia and recent head injury. It was 8 days after admission that the patient came to theatre; the fracture was immobilised in a cast in the interim.

Anaesthesia was induced with thiopentone 450 mg and tracheal intubation achieved after vecuronium 7.5 mg. Anaesthesia was maintained with N_2O, enflurane and fentanyl. The plaster cast was then removed and it was noted that there was no swelling of the limb. The patient's condition had been completely stable up to this point. However, immediately after application of an Esmarch exsanguinating tourniquet the ECG complexes were seen to alter; they became ischaemic in appearance. In addition, peripheral pulses were no longer palpable and the capnograph recorded a decrease in end-tidal CO_2 from 4% to 1%. The patient did not survive despite full resuscitative measures and a post mortem revealed occlusion of the pulmonary artery by thrombus.

In this case, as in that previously described, the problem was of thrombo-embolism that occurred after an injury to a limb. In retrospect, it could be argued that there was an excessive delay before surgery on our patient and that this period of immobility significantly increased the risk of leg or pelvic vein thrombosis. However, we consider that the main lesson to take from our experience is that in such high-risk patients the use of exsanguinating tourniquets may well precipitate thrombo-embolism and should therefore be avoided. In fact, the association between exsanguinating tourniquets and thrombo-embolism and indeed paradoxical thrombo-embolism is already described.[1] Simple elevation of the limb in high risk patients before application of the thigh tourniquet should suffice.

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Reference

1. AUSTIN M. The Esmarch bandage and pulmonary embolism. *Journal of Bone and Joint Surgery* 1963; **45B:** 384–5.

A reply

Thank you for the opportunity to reply to Drs Callander and Evans. I fully agree with their recommendation that exsanguinating tourniquets should be avoided in patients at high risk of thrombo-embolism. However, as stated in our case report, an Esmarch bandage was not used in our patient and thrombo-embolism probably occurred at the time of release of the arterial tourniquet. Hofmann and Wyatt[1] described a case of fatal pulmonary embolism in a 76-year-old female undergoing skin grafting to the leg 6 weeks after a compound tibial fracture. Thrombo-embolism occurred 2 minutes after inflation of the arterial tourniquet, without prior use of an Esmarch bandage, and these authors recommended avoidance of both exsanguination procedures *and* arterial tourniquets in patients undergoing delayed limb surgery.

The more important point raised by Drs Callander and Evans is the delay between injury and surgery. The combination of head injury and limb injury which requires surgery is relatively common and anaesthetists are understandably reluctant to administer general or spinal anaesthesia to such patients soon after head injury. However, we are perhaps less aware than our surgical colleagues of the high incidence of venous thrombosis in patients immobilised after trauma to the lower limb. Forty-five percent of patients with tibial fracture develop deep venous thrombosis in the absence of prophylaxis.[2] Pollard *et al.*[3] described fatal pulmonary embolism in a 57-year-old male undergoing delayed internal fixation of tibial and fibular fractures and recommended that active prophylaxis against deep venous thrombosis should be considered in all such patients. An added reason to operate as early as possible is if the limb injury contraindicates the pre-operative use of antithrombotic measures.

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References

1. Hofmann AA, Wyatt RWB. Fatal pulmonary embolism following tourniquet inflation. *Journal of Bone and Joint Surgery* 1985; **67A:** 633–4.
2. Hjelmstedt A, Bergvall V. Incidence of thrombosis in patients with tibial fractures. A phlebographic study. *Acta Chirurgica Scandinavica* 1968; **134:** 209–18.
3. Pollard BJ, Lovelock HA, Jones RM. Fatal pulmonary embolism secondary to limb exsanguination. *Anesthesiology* 1983; **58:** 373–4.

Bradycardia and asystole associated with trigeminal ganglion injection

A 75-year-old man with trigeminal neuralgia presented for glycerol injection of the trigeminal ganglion. His medication was carbamazepine 200 mg three times a day; the electrocardiogram was normal, with a P–R interval of 0.2 msec. The patient was unpremedicated, and the procedure was performed in the Radiology department under sedation, which consisted of midazolam 5 mg and fentanyl 75 μg given incrementally. The ECG was monitored continuously. The patient became restless, sweaty and pulseless as the needle was inserted into Meckel's cave. He was successfully resuscitated with external cardiac massage and intravenous atropine, but the procedure was abandoned.

The records of all patients who had this procedure at the Radcliffe Infirmary, Oxford, during the last 5 years were reviewed in order to determine the incidence of bradycardia or asystole during trigeminal ganglion injection. Anaesthetic records were available in 55 (89%) of these patients, who underwent a total of 81 injections, either of glycerol[1] or alcohol. The majority (78%) of patients were on carbamazepine, which has quinidine-like properties and may delay atrioventricular conduction.[2] All procedures were performed either under neuroleptanaesthesia or under light sedation. Sixty-two percent of patients were premedicated, but with atropine in only three cases. The ECG was monitored throughout in all cases.

The peri-operative complications of trigeminal ganglion injection were haematoma, from inadvertent puncture of a branch of the maxillary artery, in 11% of cases; miscellaneous problems (such as inadequate sedation in the absence of an anaesthetist) in 6% cases; and bradycardia or asystole in 8% cases. None of the patients who had a bradycardia had an anticholinergic premedication. Analysis of the pre-operative ECGs revealed that out of the total group of 55 patients, seven had first degree heart block; of these, one developed bradycardia and one had asystole at the moment of injection. A further nine patients had P–R intervals at the upper limit of normal, (0.2 msec) and, in this group, one developed asystole and two bradycardia. No patient who was known to have a P–R interval of less than 0.2 msec developed a bradydysrhythmia.

There are several conclusions to be drawn from this survey. Firstly, all patients who present for trigeminal ganglion injection should have a pre-operative ECG, since patients with delayed atrioventricular conduction are at increased risk of bradycardia. The reason for A–V conduction delay in this group may be because of the relatively elderly age of these patients, and may possibly result from the large doses of carbamazepine with which they are treated. Premedication with atropine should be considered in all patients, especially in those with a P–R interval of 0.2 msec or greater.

Secondly, sedation or neuroleptanaesthesia given by an anaesthetist must provide acceptable surgical conditions in all cases. The surgeon working alone cannot provide good sedation. Thirdly, the ECG should be monitored continuously, and intravenous access maintained throughout the procedure. Atropine should be ready if the patient has not received an anticholinergic premedication.

Trigeminal ganglion injection may be regarded as a comparatively trivial procedure, performed in the recesses of the X ray department. However, the patient must be assessed pre-operatively, and atropine premedication considered. An experienced anaesthetist must be present during the procedure, both to provide acceptable sedation and to treat any bradydysrhythmia.

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References

1. Hakanson S. Trigeminal neuralgia treated by the injection of glycerol into the trigeminal cistern. *Neurosurgery* 1981; **9:** 638–46.
2. Beermann B, Edhag O. Side effects of drugs: depressive effects of carbamazepine on idioventricular rhythm in man. *British Medical Journal* 1978; **2:** 171–2.

External transthoracic pacemaking

A 61-year-old man presented for replacement of an abdominal pacemaker which was eroding the abdominal wall. He had been pacemaker-dependent for 22 years as a result of atrioventricular dissociation. He had developed superior vena caval obstruction and subsequently had been paced epicardially after numerous replacements of endocardial leads.

Anaesthesia was induced, after lorazepam 2 mg premedication with thiopentone 200 mg, fentanyl 75 μg and droperidol 1.26 mg. Vecuronium bromide 8 mg was used to facilitate tracheal intubation. Inhalation agents were nitrous oxide, oxygen and isoflurane (0.5–1%). Surgery proceeded and during pacemaker mobilisation the epicardial lead fractured and caused asystole with loss of cardiac output. Isoprenaline to 100 μg had no effect and external cardiac massage was started while an external cardiac pacemaker (Pace Aid Cardiac Resuscitator Corporation, Portland, Oregon) was brought to theatre and applied. Asynchronous pacing was established at a rate of 80/minute and an output of 80 mA. A stable blood pressure (105/80 mmHg) was maintained easily for 15 minutes while the lead was repaired and the new pacemaker resited. A high current was required for capture so extraneous muscle twitching occurred which caused surgical difficulty; this was abolished rapidly with vecuronium bromide 2 mg. The patient made a complete recovery and had no postoperative muscle pains.

Emergency cardiac pacing can be achieved either by invasive methods or by means of a Noninvasive Temporary Pacemaker (NTP).[1] The transvenous route can be used for blind passage of a temporary electrode; in addition transvenous balloon flotation electrodes[2] have been developed for emergency pacing. However, these methods require time and skill and have associated complications; in this case, for example, only the femoral route was available.

Transoesophageal pacing is effective for atrial pacing but less reliable for ventricular pacing[3] as would have been necessary in the case reported. A transmyocardial electrode may be inserted from a subxiphoid approach or a transcutaneously inserted hypodermic needle attached to the active pacemaker terminal. However, those methods require caution to avoid potential major complications.

Successful pacing with restoration of an adequate blood pressure was lifesaving in this patient and allowed time for repair of the epicardial lead under optimal conditions. We recommend that NTP would be a useful facility to have in any operating suite and particularly when pacemaker surgery is performed. It requires no special training, can be quickly applied and carries no intrinsic mortality.

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References

1. ZOLL PM, ZOLL RH, BELGARD AH. External noninvasive electrical stimulation of the heart. *Critical Care Medicine* 1981; **9:** 393–4.
2. LANG R, DAVID D, KLEIN HO, DI SEGNI E, LIBHABER C, SARELI P, KAPLINSKY E. The use of the balloon-tipped floating catheter in temporary transvenous cardiac pacing. *Pace* 1981; **4:** 491–6.
3. CHUNG DC, TOWNSEND GE, KERR CR. The optimum site and strength-duration relationship of transesophageal indirect atrial pacing. *Anesthesiology* 1986; **65:** 428–31.

Hypotension and neurological sequelae following intramuscular midazolam

We report a case of hypotension with neurological sequelae after intramuscular midazolam as premedication. There have been no previous reports following midazolam by this route.

The patient was a 67-year-old man who weighed 80 kg with a large meningioma; he presented with a left upper visual field deficit. He had no other neurological symptoms or signs. There was no relevant past medical history apart from a subarachnoid haemorrhage treated conservatively 20 years previously. His conscious state was normal, therefore he was premedicated with midazolam 5 mg and glycopyrronium 0.2 mg intramuscularly. The patient became drowsy and dysarthric and his blood pressure, previously 150/90 mmHg, decreased to 100/70 mmHg about 5 minutes after injection. The hypotension and neurological deterioration remained unchanged for the next 15 minutes. He was transferred to the operating theatre and on arrival, approximately 30 minutes after injection, his blood pressure had spontaneously recovered to normal levels, his dysarthria had resolved but he was still drowsy. The patient received a 500-ml infusion of 0.9% saline before induction of anaesthesia and underwent an uneventful craniotomy from which he made a good recovery.

The incident could be explained by accidental intravascular injection of midazolam; however, no blood was aspirated before injection and no haematoma subsequently formed at the injection site. The patient exhibited no features of histamine release which makes anaphylaxis unlikely. It remains possible that rapid absorption of midazolam from the intramuscular injection site caused hypotension sufficient to reduce cerebral perfusion below a critical level.

Midazolam is highly water soluble at low pH and is rapidly and completely absorbed through the intramuscular route. Smith[1] found that in patients over 60 years old, the mean lag period before midazolam appeared in the plasma was 4.2 minutes. Reinhart *et al.*[2] found that the sedative and anxiolytic effects of intramuscular midazolam were evident clinically in some patients within 5 minutes.

Hypotension in the elderly after intravenous midazolam is well documented; the mechanism is a direct and indirect reduction of peripheral vascular resistance and a direct myocardial depressant effect. The magnitude of hypotension is comparable to that after thiopentone and is greater than that after intravenous diazepam.

Our patient's spontaneous recovery would correlate with the rapid redistribution and hepatic clearance of midazolam ($T_{\frac{1}{2}}\alpha$ 6–15 minutes, $T_{\frac{1}{2}}\beta$ 1.7–4 hours).[1] Alternatively, the stimulatory effect of the patient's transfer to theatre may have countered the hypotensive effect of midazolam.

In view of the efficient absorption of midazolam from the intramuscular route, coupled with the risk of intravascular injection and the known sensitivity of elderly patients to the drug, we recommend that midazolam be used for premedication with caution in patients over 60 years old.

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References

1. SMITH MT, HEAZLEWOOD V, EADIE MJ, BROPHY TO, TYRER JH. Pharmacokinetics of midazolam in the aged. *European Journal of Clinical Pharmacology* 1984; **26:** 381–8.
2. REINHART K, DALLINGER-STILLER G, DENNHARDT R, HEINEMEYER G, EYRICH K. Comparison of midazolam, diazepam and placebo I.M. as premedication for regional anaesthesia. A randomised double-blind study. *British Journal of Anaesthesia.* 1985; **57:** 294–9.

Apache II scores

We were interested to read the comments of Dr Bion and his colleagues (*Anaesthesia* 1988; **43:** 62–3) on the article by Dr Jacobs *et al.* which described their experience with Apache II (*Anaesthesia* 1987; **42:** 738–44). We would like to comment on the statistical methods used by workers in this field and to point out the errors in Dr Jacobs' reply.

The Apache II score is combined with a diagnostic category to calculate a risk of death (ROD) value for each patient. These values may then be used to audit intensive care outcome by means of a classification matrix.[1] This is most commonly achieved with a 0.5 ROD level. Dr Jacobs and co-workers have chosen to use a 0.6 ROD level so it is less easy to compare their results with other published data. Choice of this level will lead to few false positives, but unfortunately it produces many false negatives and thus lowers the sensitivity. It is perhaps contentious to suggest that such a modest increase in sensitivity as they achieved (20.8 to 29.2%) is not clinically important, and hence not

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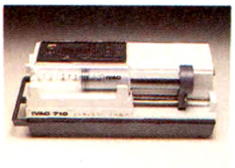

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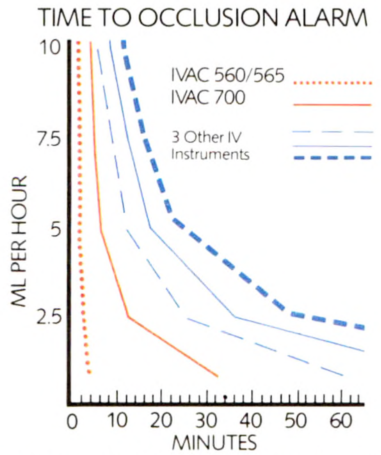

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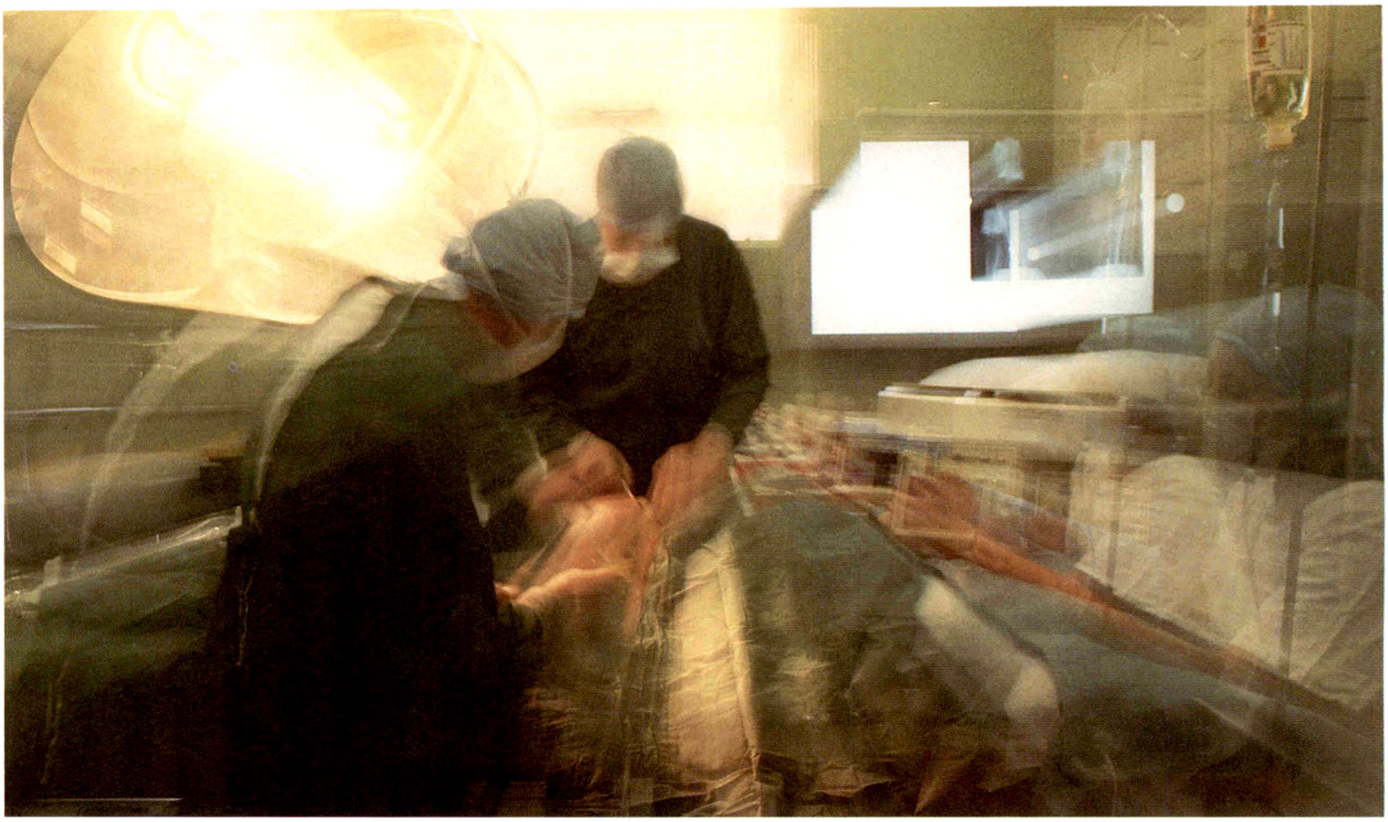

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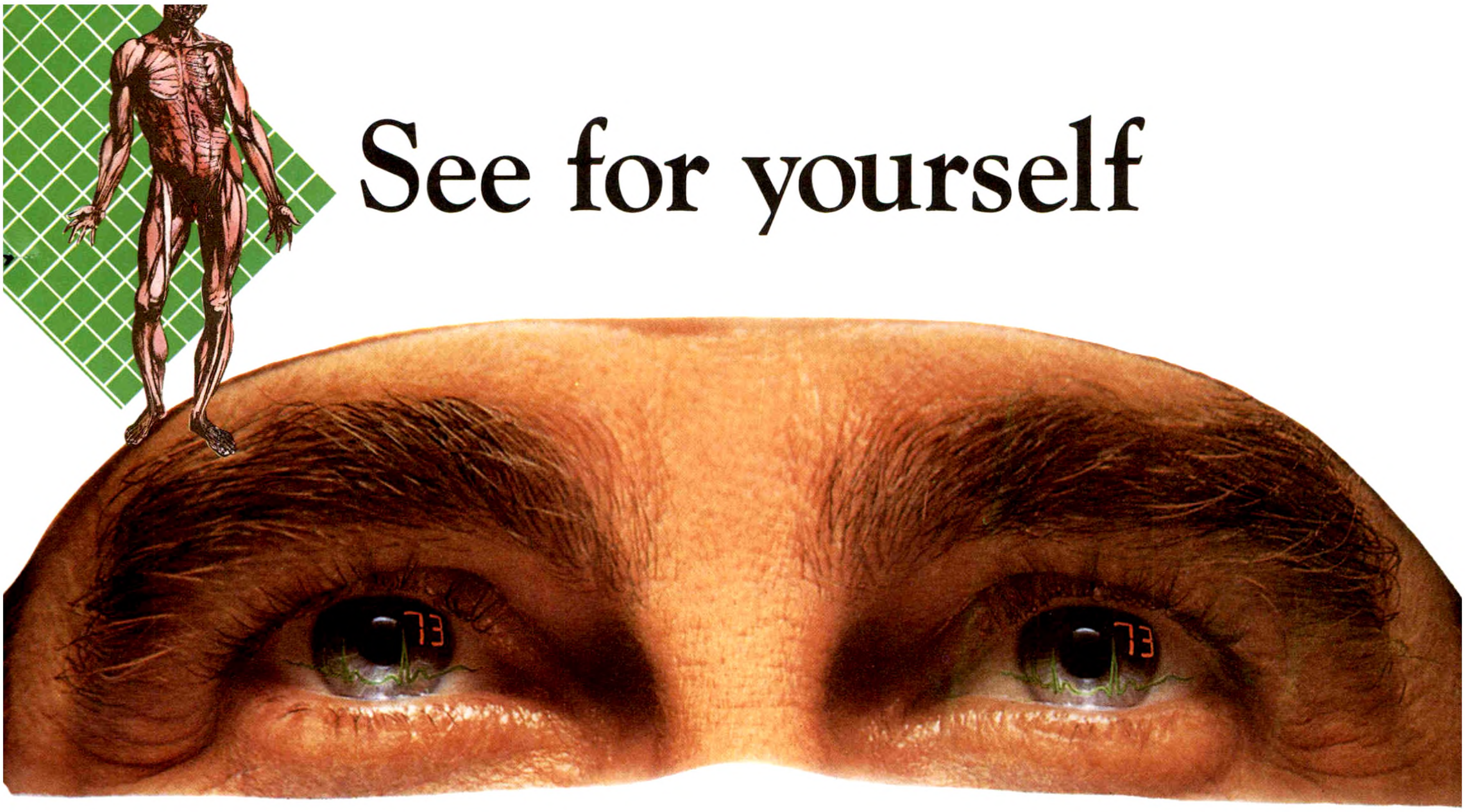

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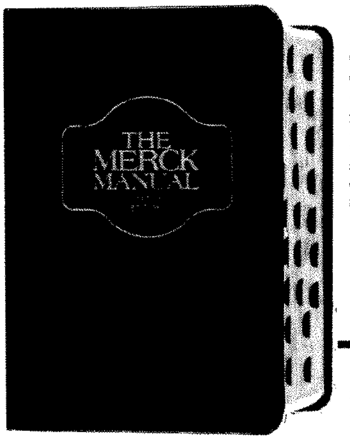

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worth the extra work involved, when compared to, say, the simpler and yet apparently equally accurate method as described by Teres and Lemeshow.[2] We would like to congratulate Dr Bion and colleagues on their success in improving the sensitivity of predicted outcome but we are wary of the development of any scoring system that is based simply on changes in the physiological state of the patient, and which takes no account of the effort needed to maintain that state. On our intensive care unit we strive to maintain our patient's oxygen delivery and consumption in the range known to equate with survival[3] and to bring other deranged variables to normal by the provision of organ system support. This approach necessarily interferes with many of the measurements of physiological adaption or decompensation found in the acute physiology score. Do other workers have a practical approach to this problem other than simply monitoring intensity of treatment using the therapeutic intervention score (TISS)?[4]

We read the remarks of Drs Jacobs, Chang and Lee in relation to the analysis of their own data, presented in Table 8 with concern. The predictive value negative (i.e. survival) in the lower half of Table 8 is 66.7%, not 29.2%. The predictive value positive (i.e. dying) and the specificity are both 100% but they are not the same thing, as is wrongly inferred on line nine of their letter. The formulae they give for specificity and sensitivity are incorrectly transposed. Dr Knaus initially regarded survival as the positive test result and, in his original[5] paper on Apache, calculated sensitivity and specificity in this way. In Apache II, and in all subsequent literature on the subject, death has been taken to be the positive result, with corresponding changes in the formulae. Such confusion over data analysis is unhelpful, and we suggest the use of the following table (Table 1) to help clarify the situation.

Table 1. Decision matrix where death is the positive result.

		Predicted		
		Alive	*Dead*	*Total*
Actual	*Alive*	1-α True negative rate specificity	α False positives	1
	Dead	β False negatives	1-β True positive rate sensitivity	1

Predictive values

$$\text{Negative} = \frac{1-\alpha}{(1-\alpha) + \beta} \qquad \text{Positive} = \frac{1-\beta}{(1-\beta + \alpha)}$$

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M. WATERS
P. NIGHTINGALE
J.D. EDWARDS

References

1. ARMITAGE P, BERRY G. *Statistical methods in medical research.* Oxford: Blackwell, 1987: 472–78.
2. TERES D, LEMESHOW S, AVRUNIN JS, PASTIDES H. Validation of the mortality prediction model for ICU patients. *Critical Care Medicine* 1987; **15:** 208–13.
3. SHOEMAKER WC. Relation of oxygen transport patterns to the pathophysiology and therapy of shock states. *Intensive Care Medicine* 1987; **13:** 230–43.
4. KEEN AR, CULLEN DJ. Therapeutic intervention scoring system: Update 1983. *Critical Care Medicine* 1983; **11:** 1–3.
5. KNAUS WA, ZIMMERMAN JE, WAGNER DP *et al.* APACHE—acute physiology and chronic health evaluation: A physiologically based classification system. *Critical Care Medicine* 1981; **9:** 591–7.

A reply

Thank you for giving us the opportunity to reply to the letter from Waters *et al.*, who comment on our response to a letter from Bion *et al.* (Anaesthesia 1988; **43:** 62–3) and our article on our preliminary experience with Apache II (*Anaesthesia* 1987; **42:** 738–44).

We have been using the Apache II for two purposes: to audit ICU performance and to develop a model to predict *individual* outcome. We agree that the commonly used method for comparison is the use of 0.5 Risk of Death. In Table 6 of our paper, we provided the mortality rates over a range of both the Apache II score and the Risk of Death (ROD). This should provide adequate data for comparison with other centres. There is however yet another way to express data for the purpose of comparison, the mortality ratio (observed mortality/predicted mortality, where predicted mortality is the mean ROD of all the patients). The mortality ratio for our patient cohort in the paper was 1.20 (observed mortality = 31% and predicted mortality = 25.9%). This can be used to compare with Knaus' series from 13 US hospitals or any other unit.[1,2]

Table 4 of our paper, which gives the mortality rates for ROD of 60%, 70% and 80%, showed the differences resulting from the use of specific diagnostic category coefficients and major organ coefficients. These data together with Table 6 record our initial attempt to develop a model to predict individual outcome. However, there are both theoretical and practical problems with our methodology. These together with our modifications have been discussed and described elsewhere.[3,4]

We are aware of the work of Teres and Lemeshow. However, they have stated that their model is useful only for group predictions and not for individual outcome predictions.[5] We are interested in the development of a model to predict individual outcome, with death as the positive result, because such a result is useful as a support for clinical decision making. The strength of the Apache II is that it is based on the concept of homeostasis and its derangement by pathological processes. The Apache II score therefore is a reflection of the interaction between the body's homeostatic mechanisms and the response to therapy on the one hand, and the pathological processes on the other. This allows it to be used in a dynamic manner (assessments over time) which correspond more closely to events in the ICU. The mortality prediction model, based on a single assessment of seven variables at time of admission, is a static model and cannot be used in this way. Our latest predictive model which uses computerised trend analysis of daily Apache II scores corrected for the presence, number and duration of organ system failures is able to predict death among individual ICU patients with a specificity of 100% and a sensitivity of up to 50%.[3,4] Our model is able to identify not only those patients who would not benefit from intensive therapy but also those who would no longer benefit. We would stress that we have *not* used our model to withhold treatment on any patient. In addition, plotting the Apache II trends enables us to record and identify the exact day when a patient suffered a deterioration. Such data can be used for rigorous analysis in our audits. Predictions are made only after at least 24 hours of ICU admission, so we do not prejudge the issue. Our model requires more data input but its additional capabilities make the extra effort worthwhile.

We are grateful to Waters *et al.* for drawing our attention to the erroneous transposition of specificity and sensitivity in our reply to Bion's letter and that the predictive value *negative* should be 66.7% and not 29.2% in Table 8 of our paper. The specificity and predictive value positive were both 100% in our data; we are aware that they do not mean the same thing and apologise for the typographical errors and the ambiguity in line nine of our letter.

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References

1. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. An evaluation of outcome from intensive care in major medical centers. *Annals of Internal Medicine* 1986; **104:** 410–8.
2. Jacobs S, Chang RWS, Lee B. Audit of intensive care: a 30 month experience using the Apache II severity of disease classification system. *Intensive Care Medicine* (in press).
3. Chang RWS, Jacobs S, Lee B, Pace N. Predicting deaths among intensive care unit patients. *Critical Care Medicine,* 1988 (in press).
4. Chang RWS, Jacobs S, Lee B. Predicting outcome among intensive care unit patients using computerised trend analysis of daily APACHE II scores corrected for organ system failure. *Intensive Care Medicine* (in press).
5. Teres D, Lemeshow S, Avrunin JS, Pastides H. Validation of the mortality prediction model for ICU patients. *Critical Care Medicine* 1987; **15:** 208–212.

DDAVP and anaesthesia

This is a report of the use of desaminocysteine-d-ammio-arginine vasopressin (DDAVP) in the anaesthetic management of a 2.5 year-old, 11 kg, Caucasian boy with Type I von Willebrand's disease[1] who presented for inguinal herniotomy under general anaesthesia.

Recent research[2] has shown that DDAVP intravenously 0.3 μg/kg causes a 3–4 fold increase of factor VIIIc and a 2–3 fold rise of factor VIII Ag in human volunteers. Early clinical work suggests that DDAVP may be useful to treat mild cases of haemophilia A, in which factor VIIIc activity is 5–20%, and Type I von Willebrand's disease.[3,4]

Pre-operative assessment was unremarkable; the patient was taking no drugs and had no history of allergy or familial history of anaesthetic problems. An intravenous infusion of 0.9% NaCl solution was started one hour before operation and 3.3 μg of DDAVP in 50 ml 0.9 NaCl was infused over 20 minutes and caused some facial flushing.

Coagulation results are shown in Table 1. Anaesthesia was induced uneventfully with thiopentone 65 mg and atropine 0.2 mg and maintained with halothane 1.5%, nitrous oxide 67% and oxygen 33%. Postoperative analgesia was provided by infiltration of 5 ml 0.25% bupivacaine with 1:200 000 adrenaline. A total of 220 ml of 0.9% NaCl solution was infused over 110 minutes and haemostasis was excellent.

Table 1. Coagulation results.

	Before DDAVP	After DDAVP (1 hour)
Prothrombin time		
Control	11.0 seconds	11.0 seconds
Patient	11.0 seconds	11.0 seconds
Partial thromboplastin time		
Control	32.5 seconds	29.0 seconds
Patient	33.5 seconds	33.5 seconds
Factor VIIIc	107%	236%
Factor VIII Ag	57%	100%
Factor VIII R	61%	164%

This case demonstrates the new role of DDAVP in the management of Type 1 von Willebrand's disease and one of the known side effects, namely facial flushing, mediated possibly by prostacyclin release. Occasionally, systemic hypotension may occur but caution must be exercised in combining DDAVP with the infusion of dextrose-containing solutions if the more serious problem of water intoxication is to be avoided. Haematological advice should always be sought, when possible, in the management of these patients.

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Montreal H3H 1P3

M.H. Plumley

References

1. Wintrobe MM. The hereditary coagulation disorders. In: *Clinical haematology*, 8th edn. Philadelphia: Lea and Febriger, 1981: 1169.
2. Mannucci PM, Canciani MT, Rota L, Donovan BS. Response of factor VIII/von Willebrand factor to DDAVP in healthy subjects and patients with haemophilia A and von Willebrand's disease. *British Journal of Haematology.* 1981; **47:** 283–93.
3. DDAVP in haemophilia and von Willebrand's disease. *Lancet* 1983; **ii:** 774–5.
4. Ruggeri ZM, Mannucci PM, Lombardi R, Federici AB, Zimmerman TS. Multimeric composition of factor VIII/von Willebrand factor following administration of DDAVP: implications for pathophysiology and therapy of von Willebrand's disease subtypes. *Blood* 1982; **59:** 1272–8.

Disadvantages of air–oxygen mixtures replacing nitrous oxide

The paper by Moseley *et al.* (*Anaesthesia* 1987; **42:** 609–12) raises some interesting issues.

The use of nitrous oxide and halothane is clearly more expensive than halothane and air–oxygen but this saving may well be at the expense of safety to the patient. Halothane is not without side effects, which on occasion can prove fatal.[1] It would appear that increasing the amount of halothane by 25% may also be accompanied by an increase in morbidity. Nitrous oxide is not free from side effects, but none have been directly and unequivocally associated with fatalities. This of course excludes the accidental administration of hypoxic mixtures of the gas; which danger is recognised and preventable. In fact nitrous oxide has an unrivalled safety record of well over a century.[2] The side effects, particularly in relation to depression of methionine synthetase and DNA synthesis, although making frightening reading,[3] and excluding those occasioned by nitrous oxide abuse 'have not produced a clinical effect recognised by generations of skillful observers'.[3] Clearly from the data (in terms of cost)[1] almost twice as much morphine was required to produce adequate postoperative anaesthesia after the regimen in which nitrous oxide was not used. This may not be a coincidence since nitrous oxide may be an opioid[4,5] and its effects have been shown to continue well after it has been discontinued both in animals[6] and humans.[7] The use of morphine is also associated with fatalities and severe untoward effects and these may be a possible further price to pay when halothane/air–oxygen is used in place of nitrous oxide and oxygen.

We must be careful not to abandon a drug on grounds of cost and 'because it is not perfect or completely harmless; we must be careful not to advocate more troublesome options.[4]

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References

1. REYNOLDS JEF, PRASAD AB, eds. *Martindale the extra pharmacopoeia*, 28th edn. London: Pharmaceutical Press, 1982: 741–3.
2. GILLMAN MA. Editorial. Haematological changes caused by nitrous oxide. Cause for concern? *British Journal of Anaesthesia* 1987; **59:** 143–6.
3. SAIDMAN LJ, HAMILTON WK. We should continue to use nitrous oxide. In: EGER E II, ed. *Nitrous oxide N_2O*. New York: Elsevier, 1985: 345–53.
4. GILLMAN MA. Nitrous oxide, an opioid addictive agent: Review of the evidence. *American Journal of Medicine*. 1986; **81:** 97–102.
5. GILLMAN MA. Analgesic (sub anesthetic) nitrous oxide interacts with the endogenous opioid system: A review of the evidence. *Life Sciences* 1986; **39:** 1209–21.
6. BERKOWITZ BA, FINCK AD, NGAI SH. Nitrous oxide analgesia: reversal by nalaoxone and development of tolerance. *Journal of Pharmacology and Experimental Therapeutics* 1977; **203:** 539–47.
7. GILLMAN MA, LICHTIGFELD FJ. Minimal sedation required with nitrous oxide-oxygen treatment of the alcohol withdrawal state. *British Journal of Psychiatry* 1986; **148:** 604–6.

Peroperative nerve injuries

We read with curiosity the report by Dr Gwinnutt (*Anaesthesia* 1988; **43:** 205–6), since we had a case of bilateral ulnar nerve injury after high abdominal surgery. The sensory deficit in our case included the medial antebrachial cutaneous nerve as well so we stated that a compressive or ischaemic injury occurred above the elbow, that is, at the medial cord of the brachial plexus. Sunderland however points out that a sensibility deficit may appear in the region of the medial antebrachial cutaneous nerve without evidence of a direct nerve injury.[1] Nevertheless, a temporary narrowing of the thoracic outlet by a surgical retractor, which exerts traction on the ribcage in a cranial and upward direction with simultaneous fixation of the feet at the distal end of the table, was considered as a possible explanation.

Upper extremity nerve injury has been reported after all types of thoracic surgery including cardiac surgery with sternal retraction.[2] People are often unconvinced in these cases about the precise cause-and-effect relationship between a particular position and the subsequent nerve injury. Therefore, in the case described by Dr Gwinnutt it would be interesting to know on which arm the Dinamap blood pressure cuff was placed and whether the surgeon was standing on the affected side. Pressure created by automatic devices with high inflation cycle frequency and pressure exerted by the surgeon, ECG wires, a Mayo stand or a screen may form other risks of nerve damage. Venous congestion, sex, pre-existing subclinical polyneuropathy are also contributory factors.[3]

We advocate the use of peroperative nerve monitoring (SSEP: SomatoSensory Evoked Potentials) in order to safeguard against injury to peripheral nerves.

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References

1. SUNDERLAND S. *Nerve and nerve injuries*, 2nd edn. London: Churchill Livingstone, 1978.
2. ZYLICZ Z, NUYTEN FJJ, NOTERMANS SLH, KOENE RAP. Postoperative ulnar neuropathy after kidney transplantation. *Anaesthesia* 1984; **39:** 1117–20.
3. ROY RC, STAFFORD MA, CHARLTON JE. Nerve injury and musculoskeletal complaints after cardiac surgery: influence of internal mammary artery dissection and left arm position. *Anesthesia and Analgesia* 1988; **67:** 277–9.

A reply

Thank you for the opportunity to reply. No record was made of which arm the Dinamap cuff was placed on, but it is my usual practice to use the opposite arm to the intravenous infusion. This would have resulted in the cuff being on the right arm in this patient. The lesion occurred in the left arm. The surgeon normally stands on the patient's left side, but with a patient in the position described the surgeon is well away from the arms. None of the other factors mentioned by Zylicz *et al.*[1] are relevant in this patient.

The only identifiable common factor on both occasions that the patient developed an axillary nerve palsy was the position adopted for surgery. This must remain as a major contributory factor.

Somatosensory evoked potentials may well be the ideal safeguard against injury to peripheral nerves, but should not detract from an understanding of the anatomy involved and extreme care when positioning anaesthetised patients.

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Reference

1. ZYLICZ Z, NUYTEN FJJ, NOTERMANS SLH, KOENE RAP. Postoperative ulnar neuropathy after kidney transplantation. *Anaesthesia* 1984; **39:** 1117–20.

Cardioplegia

In our previous letter, (*Anaesthesia* 1987; **42:** 1117) we suggested, as do Drs Fox and Russell, (*Anaesthesia* 1988; **43:** 254) that inadequate distribution of cardioplegia may have been a factor, indeed an inevitable factor in the rapid return of cardiac activity. However, this is an unusual case, and we believe that inadvertent pacing was an important additional factor.

Unipolar, and to a lesser extent bipolar diathermy can adversely affect pacemaker function resulting in significant dysrhythmias. Tissue diathermy near the pacemaker increases the likelihood of such a malfunction occuring.

We believe that diathermy-induced dysrhythmia constitutes a greater risk than that of pouch haematoma or infection. Therefore, we isolate the pacemaker electively from the patient. Diathermy is not used in pacemaker-dependent patients. The incidence of pouch haematoma or infection in this small group of patients is low.

Rather than give a fixed dose of cardioplegia, the surgeon involved requests that we infuse cold cardioplegic solution until the heart's electrical activity stops. Top-up doses are given at regular intervals after this. We continue to use this regimen, and have had no further untoward incidents.

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Continuous intravenous infusion of atracurium in idiopathic obesity

Anaesthesia in patients with morbid obesity poses particular problems since fat interferes with the pharmacokinetics of many anaesthetic agents. Previous clinical experience with atracurium infusions has demonstrated the rapid recovery and absence of cumulative effects.

A woman aged 43 years who weighed 137 kg was to have a plastic operation on her thighs. Routine pre-operative examination was within normal limits except for the presence of restrictive pulmonary disease. Droperidol 5 mg and intramuscular pethidine 50 mg was given one hour before surgery. Anaesthesia was induced with midazolam 5 mg, fentanyl 100 μg and thiopentone 300 mg. Tracheal intubation was performed after the administration of a bolus dose of atracurium of 0.5 mg/kg intravenously and anaesthesia was maintained with 66% N_2O in O_2 with supplements of fentanyl (50–100μg) and halothane (0.5–1%) intermittently during the operation.

Ten minutes before the end of the action of the bolus dose of atracurium, an infusion of atracurium through a different venous catheter (100 mg in 500 ml normal saline) was started and continued with a constant rate of 0.4 mg/kg/hour by means of an infusion pump (Diginfusa). Neuromuscular blockade was monitored throughout the anaesthesia according to the mechanical response to a train-of-four (TOF) stimulation (2 Hz) of the ulnar nerve. Arterial pressure and heart rate as well as ECG were monitored continuously throughout the operation.

Twenty-three minutes before the end of the operation the infusion was stopped. The first response of the TOF and respiratory movements were noticed within 18 minutes. Seven minutes later extubation without antidote was attempted with 90% response to the TOF within 30 minutes of withdrawal of the infusion.

The patient was placed in a semirecumbent position. No sign of recurarisation, histaminoid reaction or other postoperative problems were observed.

Non-depolarising muscle relaxants are usually given first by a loading dose, according to the patient's weight, followed by repeated doses according to clinical evaluation by the anaesthetist.[1] However, this method may produce unstable neuromuscular blockade and sometimes drug overdosage at the end of the operation. Atracurium would require repeat 3–5 injections per hour. We therefore preferred to control relaxation in this case by continuous intravenous infusion based on the method of Flynn *et al.*[2,3] The blockade was more constant (80–90%) without variations, presumably because the plasma concentration of atracurium was constant throughout the infusion.

The use of repeated injections of atracurium requires about 0.6–0.8 mg/kg/hour to maintain adequate neuromuscular blockade, whereas, by continuous infusion the corresponding dose was found[4] to be about 0.4 mg/kg/hour: a 33–50% reduction.

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A. Foustanos

References

1. Hughes R, Payne JP. Clinical assessment of atracurium using a single twitch and tetanic responses of the adductor pollicis muscles. *British Journal of Anaesthesia* 1983; **55:** 47S–52S.
2. Flynn PJ, Hughes R, Walton B, Jothilingam S. Use of atracurium infusions for general surgical procedures including cardiac surgery with induced hypothermia. *British Journal of Anaesthesia* 1983; **55:** 135S–8S.
3. Webster NR, Cohen AT. Closed-loop administration of atracurium. Steady-state neuromuscular blockade during surgery using a computer controlled closed-loop atracurium transfusion. *Anaesthesia* 1987; **42:** 1085–91.
4. Payne JP, Hughes R. Evaluation of atracurium in anaesthetized man. *British Journal of Anaesthesia* 1981; **53:** 45–54.

Dose of glycopyrronium

The report by Dr Pratt of three cases of bronchospasm occurring after reversal of neuromuscular block with neostigmine and glycopyrronium (*Anaesthesia* 1988; **43:** 248) is interesting.

Hammond *et al.*[1] measured specific airway conductance after the administration of neostigmine with either atropine or glycopyrronium. Clinically significant reduction in conductance was not observed in any of their patients.

A likely explanation for Dr Pratt's observation lies in the dose of glycopyrronium used. The Product Licence for Robinul Injection (glycopyrronium) states that 0.5 mg glycopyrronium should be given with 2.5 mg neostigmine. Dr Pratt used 0.3–0.4 mg glycopyrronium; our experience with the cardiovascular and sialogogue effects of neostigmine suggest that these doses may be too low to effectively block the muscarinic effects of 2.5 mg neostigmine.

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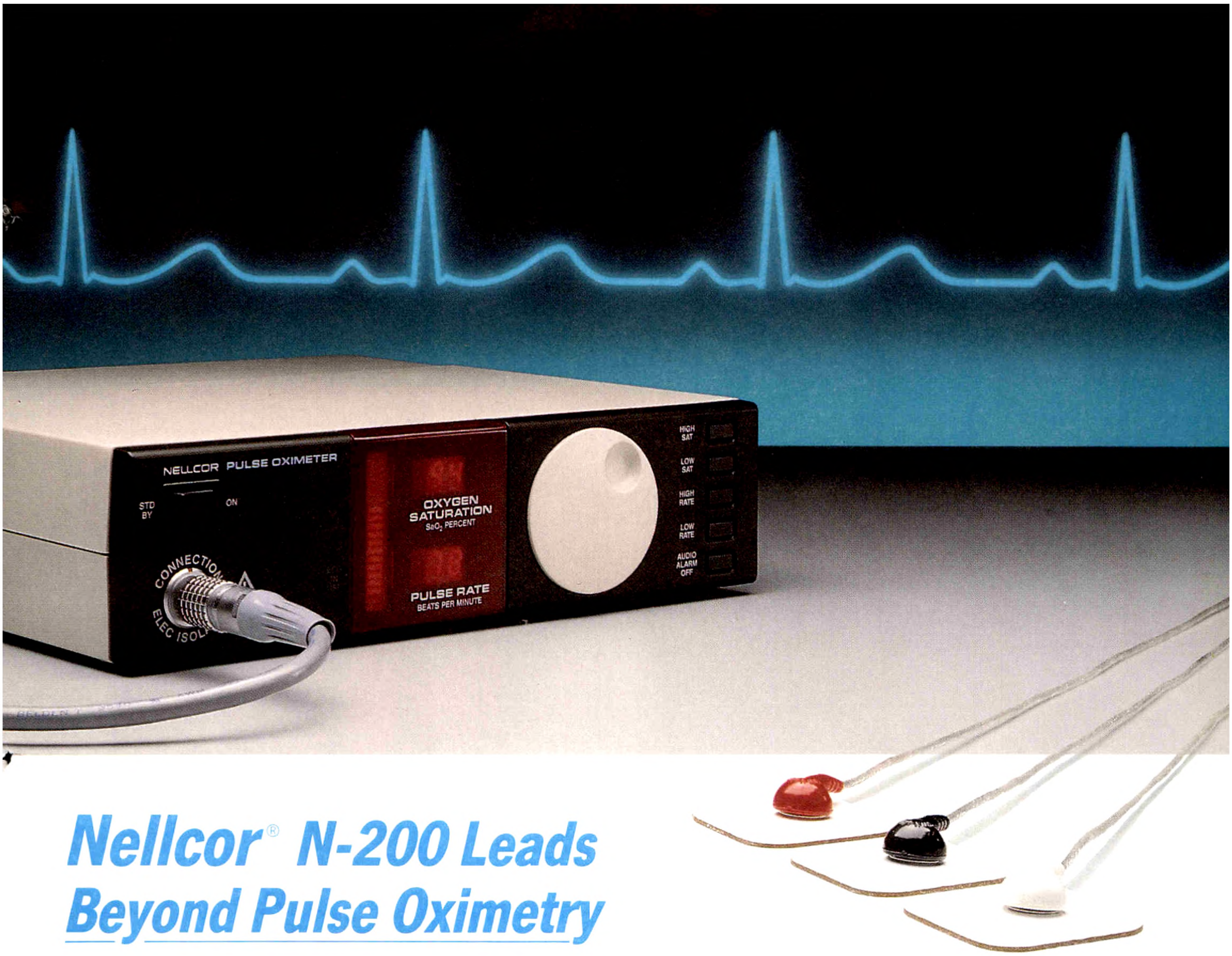
Reference

1. Hammond J, Wright D, Sale J. Pattern of change of bronchomotor tone following reversal of neuromuscular blockade. Comparison between atropine and glycopyrrolate. *British Journal of Anaesthesia* 1983; **55:** 955–9.

Minitracheostomy and laryngectomy

We report the use of a minitracheostomy tube in the management of two patients who required total laryngectomy and radical neck dissection. The first patient was a 63-year-old man who presented with a 9-month history of a hoarse voice and increasing shortness of breath over the preceding 4 weeks. On examination he was short of breath at rest



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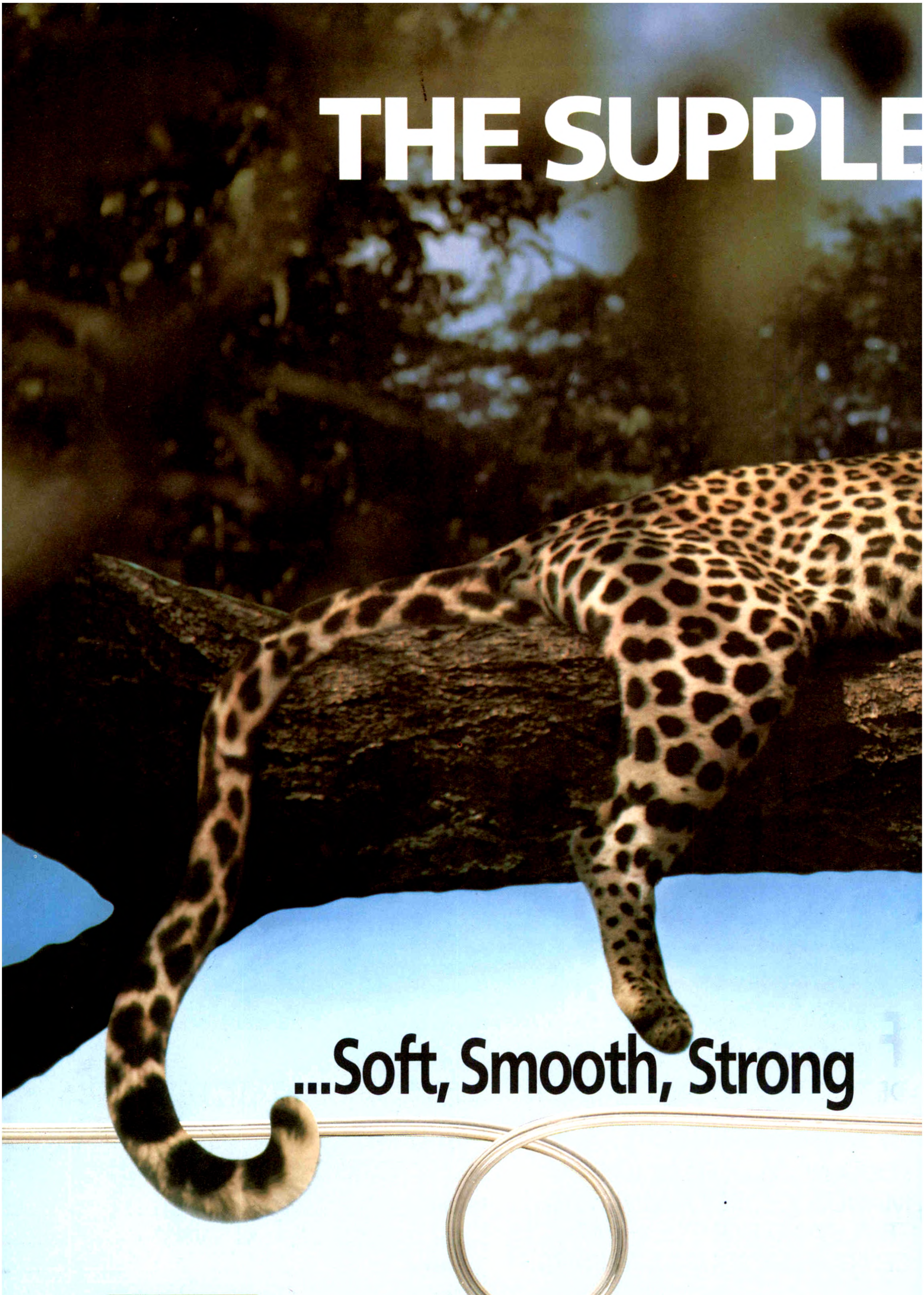

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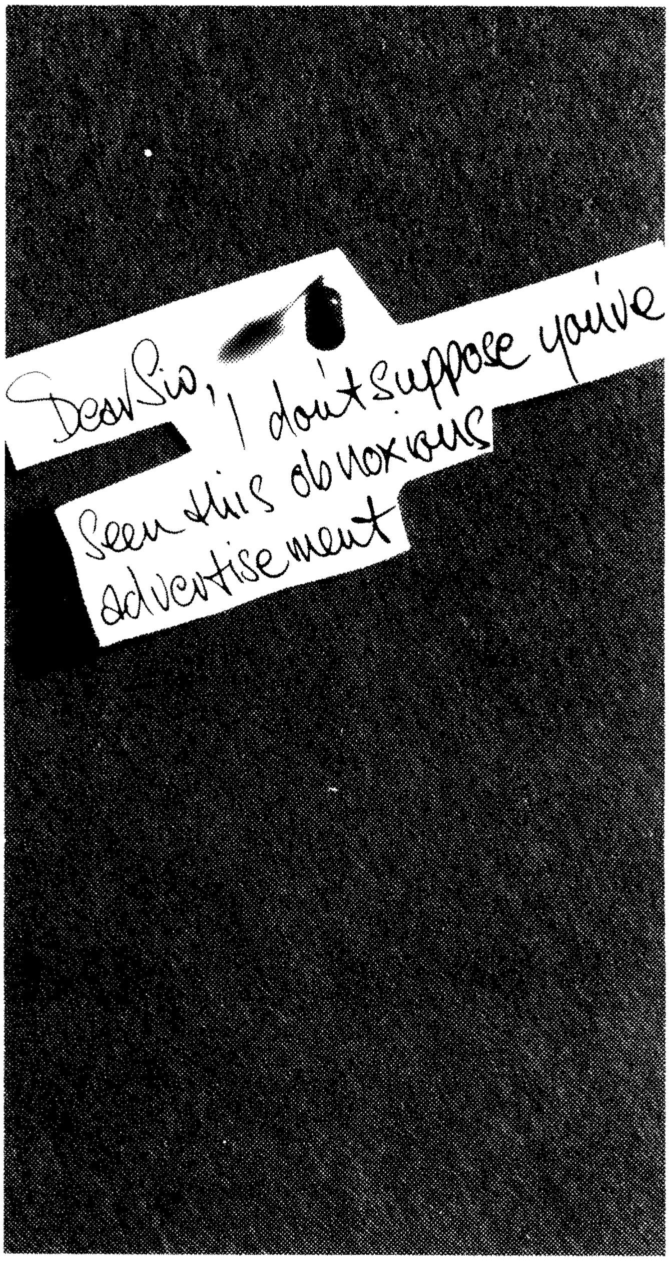
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with obvious stridor. Fibreoptic laryngoscopy revealed a large right supraglottic tumour which obscured the vocal cords and subglottis and fixed the right hemilarynx. A firm lymph node was palpable in the right mid-deep cervical chain. The patient's stridor was eased by the administration of intravenous hydrocortisone, antibiotics and humidified oxygen. Fine needle aspiration of the neck gland was positive for atypical squamous cells. Laryngeal tomography showed a transglottic mass destroying the right hemilarynx and severely obstructing the airway.

The patient was therefore scheduled for total laryngectomy and right radical neck dissection preceded by biopsy for frozen section to confirm the presumptive diagnosis of a squamous cell carcinoma. We considered that any form of sedation or general anaesthesia was contraindicated in this patient, and therefore decided to use a minitracheostomy tube (Portex: 4 mm internal diameter) inserted through the cricothyroid membrane under local anaesthesia at the beginning of the operation. This was performed in the operating theatre by the surgeon. Once the patient's airway had been secured through the minitracheostomy tube, general anaesthesia was induced, the patient's larynx fully examined and biopsied and then intubated with an orotracheal tube. The minitracheostomy tube was removed and the operation successfully performed.

The second patient was a 53-year-old man with a large carcinoma of the larynx which was treated in another hospital with radiotherapy with no resolution of the tumour. He was admitted with increasing difficulty in breathing and laryngeal tomography showed he had virtually no airway. He was therefore listed for assessment of tumour, proceeding to laryngectomy and radical neck dissection. We considered that any form of sedation or general anaesthesia was contraindicated. We therefore inserted a minitracheostomy tube under local anaesthesia in the operating theatre and then proceeded with general anaesthesia, assessment and operation as with the first case.

The use of a minitracheostomy before laryngectomy in patients with severe airway obstruction has distinct advantages over the more conventional formal tracheostomy under local anaesthesia. Firstly, insertion of a minitracheostomy tube using a local anaesthetic is far less distressing for the patient (and surgeon) than tracheostomy under local anaesthesia. Secondly, the presence of the minitracheostomy tube with a patient fully anaesthetised and paralysed allows optimal conditions for assessment of the tumour and passage of a tracheal tube. Thirdly, the track formed when inserting a minitracheostomy is smaller than that formed by a tracheostomy and can be excised as part of the conventional skin incision allowing a simpler surgical dissection and construction of a permanent stoma in the lower skin flap at the end of the operative procedure.

We wholeheartedly recommend this technique for the patients with severe airway obstruction prior to radical surgery.

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Flumazenil

The recent article by Bodenham, *et al.* (*Anaesthesia* 1988; **43:** 376–8) about the use of prolonged flumazenil infusion to reverse sedation produced by midazolam was interesting. The current cost of flumazenil to this hospital is £16.32 per 0.5 mg ampoule. Simple calculation reveals that the total cost of infusion at £16.32 per hour for 8 days would be £3133.44. Is this an expensive method of preserving the ability to cough spontaneously?

Kingston Hospital, R.J. TELFORD
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Benzydamine cream in post-herpetic neuralgia

There have been many anecdotal reports of benzydamine hydrochloride cream providing symptomatic relief from post herpetic neuralgia. Alexander[1] reported a retrospective study which tended to confirm this effect.

A double blind prospective study was conducted to investigate the effect of benzydamine cream on post-herpetic neuralgia (PHN). Forty-nine patients referred to pain clinics for treatment of PHN were admitted to the trial over a period of 2 years. Patients kept a pain diary over an initial one-week period in which they daily scored their pain from 0 (no pain) to 3 (severe pain). They were then allocated randomly on a double blind-basis to receive either benzydamine 3% cream or inactive base cream (placebo) and told to apply the cream to the painful skin up to 6 times a day and continue to keep a daily record of their pain score. They were then supplied with the alternative (benzydamine or placebo) after 2 weeks' use of the first cream with the same instructions for a further 2 weeks.

Seven patients dropped out of the study; three as a result of skin irritation (one with placebo) and four who failed to complete records. Of 21 patients who received the benzydamine cream first, 52% reported a reduction of pain (change in mean pain score −0.6). Only 38% maintained this improvement (change in mean pain score +0.19) when these patients then changed to placebo cream.

Of 21 patients who received placebo first, 38% showed a reduction of pain (change in mean pain score −0.3) but when these changed to benzydamine 52% experienced reduced pain (change in mean pain score −0.3). Results were unrelated to patient's age, duration of symptoms or affected dermatome.

The mechanism of action of benzydamine in PHN is open to speculation, but the poorer results with placebo suggest that the act of massaging the skin is not the only factor. Benzydamine is known to have some local anaesthetic properties, but the effects of the cream in PHN appear to be unlike those produced by local skin anaesthesia or peripheral nerve blocks.

Post herpetic neuralgia is often an intractable and distressing condition for which most 'treatments' are at best only partially effective. The results in this trial do not reach statistical significance with these numbers, but we think that this is a useful clinical result which suggests that benzydamine has a place in the symptomatic relief of some of these patients.

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Reference

1. ALEXANDER J. Post-herpetic neuralgia. *Anaesthesia* 1985; **40:** 1133–4.

Hazard of piggy-backing intravenous infusions

This is a report of a case of profound fetal bradycardia induced by an accidental overdose of syntocinon during labour. A 25-year-old primiparous woman, with a history of systemic lupus erythematosus controlled by systemic steroids, presented at 37 weeks' gestation for induction of labour. She requested epidural analgesia once labour was established following artificial rupture of membranes. An intravenous infusion of lactated Ringer's solution and an infusion of syntocinon (through a volumetric infusion pump) were started. Both solutions were infused through the same 18-G cannula. The syntocinon infusion was connected to the cannula by piggy-backing with a 20-G intravenous needle through the distal injection port of the other intravenous line. This technique is common practice in both Canada and the United Kingdom.

The patient's labour proceeded uneventfully until the first epidural top-up, after which she became moderately hypotensive (systolic blood pressure 85 mmHg) and the fetal heart tracing showed decreased variability. The patient was then placed in the left lateral position and an infusion of lactated Ringer's solution was started. Flow was slow through the original cannula, so this was replaced and the two administration sets were reconnected to the second cannula. Rapid infusion of fluid quickly corrected the maternal hypotension, but the uterus became hypertonic and this was accompanied by profound fetal bradycardia. An overdose of syntocinon was suspected; both infusions were immediately stopped, oxygen was given, and preparations were made for emergency Caesarean section. The fetal heart rate began to recover towards its previous rate as uterine tone diminished after a further 7 or 8 minutes. The patient was allowed to continue in labour and had an uneventful vaginal delivery 2 hours later.

This case report highlights the danger of piggy-backing multiple intravenous infusions through the same cannula, particularly when one infusion is administered by an infusion pump. It seems likely that this patient received a large bolus of syntocinon which had accumulated in the second intravenous line when the original cannula was blocked. There is no easy way to determine whether or not contamination of piggy-backed lines has occurred, so intravenous infusions of potent drugs should ideally be administered through separate cannulae from normal maintenance fluids. Solution administration sets with check valves to prevent retrograde flow must be employed if separate cannulae cannot be used.

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A. Ewen

A simple arrangement to sample expired gas in small children

Measurement of end-tidal CO_2 in infants and children who weigh < 12 kg depends on the site of expired gas sampling; distal sampling from the tracheal tube results in a significantly closer approximation to arterial $P\text{CO}_2$ than proximal sampling.[1]

We have devised a simple arrangement to sample expired gas from within the tracheal tube which uses disposable equipment that is readily available in paediatric theatres (Figs 1 and 2). This arrangement incorporates the Portex Mini-link system. The venous cannula used to aspirate gas from within the tracheal tube can easily be renewed between cases in the interests of sterility.

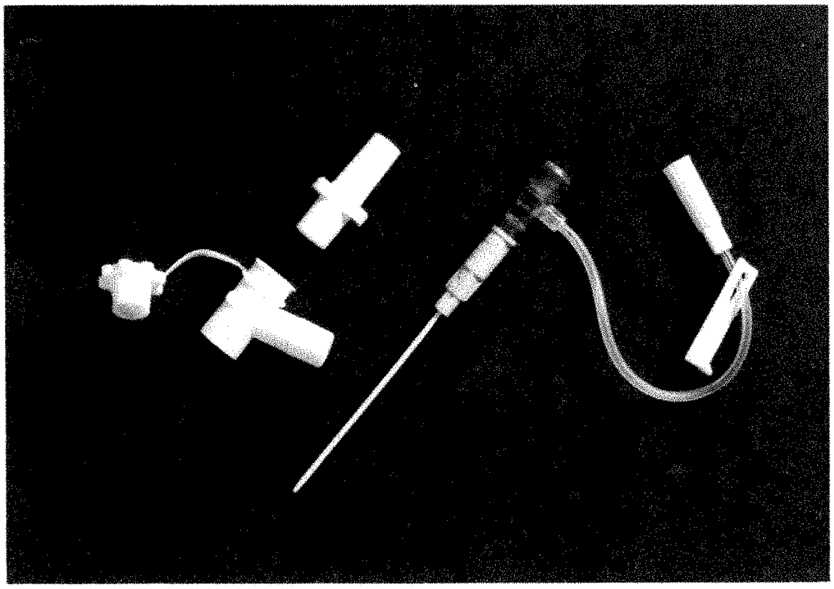

Fig. 1. Component parts of the expired gas sampling arrangement; 8.5/6.0 mm Mini-link tracheal tube connector, 8.5 mm Mini-link angled connector, intravenous cannula (Abbocath), and an extension set with 'T' (Venisystems).

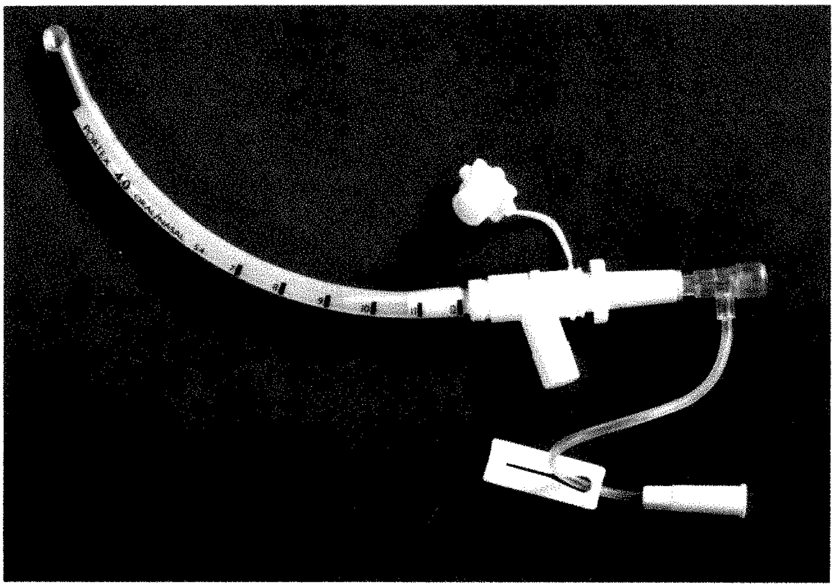

Fig. 2. The complete assembly attached to a tracheal tube.

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M.F. Reid
A. Matthews

Reference

1. Badgwell JM, McLeod ME, Lerman J, Creighton RE. End-tidal $P\text{CO}_2$ measurements sampled at the distal and proximal ends of the endotracheal tube in infants and children. *Anesthesia and Analgesia* 1987; **66:** 959–64.

Identification of cerebrospinal fluid

Glucose test strips are reported to be useful to distinguish cerebrospinal fluid (glucose = 45–85 mg/dl) from local anaesthetics.[1] However, Saddler reported that the BM-Test-Glycemic 20–800 (Boehringer, Mannheim) test strips reacted falsely positive when normal saline was applied to the glucose test strip zones.[2] We conducted a blinded study that compared the reactivity of preservative-free normal saline, cerebrospinal fluid and CSF mixed with saline in dilutions of 1:1, 1:10 and 1:20 using four different test strips (2 urine and 2 blood). Each brand of test strip was tested 10 times. Saline did not react positively with any of the glucose test zones in our study (Table 1).

The reactivity of all the test strips used in our study is based on a double enzymatic reaction. Glucose oxidase catalysed the oxidation of glucose to produce hydrogen peroxide. Peroxidase catalysed the reaction of hydrogen peroxide with a potassium iodide chromogen to cause a change of colour in the test strip. Glucose or hydrogen peroxide would have had to be present in the solution tested to cause a colour change on the test strips analysed.

The BM-Test-Glycemic 20–800^R strip is the European equivalent of the Chemstrip-bG^R in the United States. The Chemstrip-bG was one of four brands of test strips used that was used in our study. We raise the question as to whether or not the saline applied to the test strip by Dr Saddler could have been contaminated with glucose or hydrogen peroxide. We have found the glucose zones of the test strips to be effective in detecting cerebrospinal fluid from epidural catheters and we have subsequently detected epidural catheter migration into the subarachnoid space on several occasions, confirmed by contrast media and X ray, using the Chemstrip-bG^R test strips.

Table 1. Quantitative glucose responses (mg/dl).

	Type of strip			
	C	N	Cb	D
Saline	0	0	0	0
CSF	100	100	80	90
1:1 (CSF:saline)	100	100	80	90
1:10 (CSF:saline)	50	0*	20	25
1:20 (CSF:saline)	50	0*	20	25

* $p < 0.05$; C, Chemstrip-9^R (Boehringer Mannheim); N, N-Molstix^R (Ames); Cb, Chemstrip-bG^R (Boehringer Mannheim); D, Dextrostix (Ames).

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References

1. Berry A. Test for spinal fluid. *Anaesthesia* 1958; **13:** 100–1.
2. Saddler JM. Falsely positive reaction to glucose test strips. *Anaesthesia* 1985; **40:** 601.

A case of convulsion after propofol anaesthesia

The effect of propofol on the convulsive threshold has not been determined in man. A recent report indicated a convulsive effect in patients with temporal lobe epilepsy.[1] However, in another report on 10, nonepileptic patients given propofol no epileptiform changes were noted using a brain function monitor.[2]

A 31-year-old male patient, with no previous medical history, was anaesthetised for a vasectomy with propofol 2.5 mg/kg and intermittent boluses to a total dose of 5 mg/kg. Anaesthesia was supplemented with nitrous oxide/oxygen and halothane 0.5%. Half an hour after recovering from uneventful anaesthesia he developed a major seizure with tonic and clonic phazes. The fit resolved spontaneously. An electroencephalogram afterwards was normal.

The case indicates the possible convulsive effects of propofol or its metabolite and that further studies should be carried out to investigate this.

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R.A.P. Victory
D. Magee

References

1. Hodkinson BP, Frith RW, Mee EW. Propofol and the electroencephalogram. *Lancet* 1987; **2:** 1518.
2. Yate PM, Maynard DE, Major E, Frank M, Verniquet AJW, Adams HK, Douglas EJ. Anaesthesia with ICI 35,868 monitored by the cerebral function analysing monitor (CFAM). *European Journal of Anaesthesiology* 1986; **3:** 159–66.

Recurrent opisthotonus associated with anaesthesia

This is a report of a case of opisthotonus associated with propofol anaesthesia, with recurrent attacks up to 4 weeks postoperatively. A fit 29-year-old female presented for arthrodesis of a toe. She had a history of anorexia nervosa several years previously. Her daughter was taking anticonvulsant therapy and her sister had experienced a single convulsion, but was not on treatment.

She was premedicated with morphine 10 mg and atropine 0.6 mg. Anaesthesia was with propofol 150 mg (2.5 mg/kg) with 10 mg lignocaine. Enflurane with nitrous oxide and oxygen was introduced and adjusted to maintain a 1.5% end-tidal concentration. Local blockade of the foot was performed using 18 ml of 0.375% bupivacaine. The anaesthetic was uneventful and an end-tidal $P\text{CO}_2$ of 50–60 mmHg was maintained. The tourniquet was deflated after 33 minutes. She breathed 100% oxygen and opened her eyes to command within 5 minutes. Twenty minutes later facial twitching was noticed, followed by abnormal chewing activity. She developed opisthotonus with hyperextension of the neck and extension of upper and lower limbs that lasted 30–40 seconds, followed by a grand mal seizure. This was terminated with 10 mg Diazemuls intravenously. Plasma bupivacaine concentration at this time was 0.21 μg/ml. She had recurrent seizures during the next hour and was started on an infusion of Diazemuls and transferred to Intensive Care. She had recurrent seizures over the next 48 hours that consisted of either tonic-clonic seizures or opisthotonic attacks associated with apnoea.

She had a brain scan because of the frequency of these attacks. General anaesthesia consisted of thiopentone, suxamethonium, nitrous oxide and oxygen by controlled hyperventilation with vecuronium to maintain relaxation. The computerised tomographic scan was normal but recurrent opisthotonic/apnoeic attacks of increasing frequency followed and she was sedated and ventilated with midazolam and morphine by infusion. A lumbar puncture was performed and CSF analysis was normal. She was weaned from ventilation with difficulty and suffered apnoeic attacks with extensor posturing. An electroencephalogram showed generalised slow wave activity consistent with sedation. The epileptiform seizures diminished on commencing phenytoin, but the episodes of opisthotonus were unaffected. A repeat EEG at 3 weeks was reported as showing no evidence of epileptiform activity. The last episode of opisthotonus occurred 23 days postoperatively. She remained lethargic and anorexic mobilising slowly and was discharged 7 weeks after surgery.

Her abnormal behaviour may have resulted from exposure to enflurane in a subject with a familial epileptic tendency, but the recent reports of opisthotonic reactions occurring during recovery from propofol anaesthesia suggest that there may be dual aetiology in this case.[1] Opisthotonus is not a common manifestation of epilepsy and has not been reported following an enflurane anaesthetic. It is, however, one of several versions of an acute dystonic reaction that may be seen typically after administration of phenothiazine-type drugs.[2] The seizures may be related to enflurane exposure, although a fit was reported in an epileptic who had an opisthotonic reaction after propofol with no exposure to enflurane.[3]

All the reported cases had received opiates, and it is known that fentanyl increases the plasma concentration of propofol by up to 50%. In three cases lignocaine (10–20 mg) was mixed with the propofol; there are no data on possible pharmacological changes this may produce.

The aetiology of acute dystonic reactions is unclear but relates to interaction with neurotransmitters in the central nervous system. The euphoric mood sometimes seen during recovery from propofol and accumulating evidence of specific antiemetic action indicate possible action at dopaminergic and other sites. The prolonged time course is difficult to relate to the short action of propofol, but its metabolites may be implicated. It is interesting that administration of the anticholinergic procyclidine did not influence the abnormal movements in the first case reported.[4]

The exact cause of these reactions remains uncertain but as this case demonstrates prolonged abnormal behaviour may result. It may be prudent to avoid the use of propofol with enflurane in patients with any personal or family history of epilepsy or psychiatric disorder at the present time.

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References

1. Laycock GJA. Opisthotonus and propofol: a possible association. *Anaesthesia* 1988; **43:** 257.
2. Gaca JMS, Gore JM, Pratter MR. Anticholinergic poisoning. In: Rippe JM, Irwin RS, Alpert JS, Dalen JE, eds. *Intensive care medicine*. Boston/Toronto: Little, Brown, 1985: 936.
3. Cameron AE. Opisthotonus again. *Anaesthesia* 1987; **42:** 1124.
4. Dingwall AE. Oculogyric crisis after day case anaesthesia. *Anaesthesia* 1987; **42**: 565.

Propofol, opisthotonus and epilepsy

Dr A.E. Cameron (*Anaesthesia* 1987; **42:** 1124) reported opisthotonus and a late grand mal fit in an epileptic patient who presented for dilatation and curettage and was anaesthetised with fentanyl, propofol and lignocaine. A possible association between grand mal seizure and propofol was postulated.

This report concerns a case of status epilepticus after anaesthesia that involved propofol. A 27-year-old female with inter-menstrual bleeding presented for dilatation and curettage. Three months earlier the diagnosis of idiopathic temporal lobe epilepsy was made and she was receiving sodium valproate 400 mg twice a day. A computerised tomographic brain scan was entirely normal. Her last seizure occurred 5 days before admission.

Premedication was omitted; induction consisted of propofol 150 mg and alfentanil 0.5 mg and maintenance was with nitrous oxide 66% in oxygen supplemented with halothane. Induction and maintenance of anaesthesia were without incident. She had a grand mal seizure in the recovery room before consciousness was regained. The seizure was ablated with thiopentone, but further seizures occurred during the subsequent 90 minutes despite further doses of barbiturate and benzodiazepine. (Total doses: thiopentone 500 mg; diazepam 30 mg.) Intravenous phenytoin was added to her medication and seizure activity ceased. Her subsequent recovery was uneventful and she was discharged after 48 hours with an early appointment to see her own neurologist.

Hodkinson *et al.*[1] have reported the occurrence of epileptiform activity in three patients who had propofol; Rampton *et al.*,[2] however have demonstrated a shorter fit duration with electroplexy after propofol compared with methohexitone. The epileptogenic potential of propofol, therefore, remains unclear. Our experience suggests that it may be prudent to avoid its use in epileptic patients.

A report has been submitted to the Committee for Safety of Medicines.

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References

1. HODKINSON BP, FRITH RW, MEE EW. Propofol and the electroencephalogram. *Lancet* 1987; **2:** 1518.
2. RAMPTON AJ, GRIFFIN RM, DURCAN JJ, STUART CS. Propofol and Electroconvulsive Therapy. *Lancet* 1988; **1:** 296–7.

Isoflurane for conscious sedation

Isoflurane sedation can indeed give good operating conditions when used for sedation in dental patients as Drs Rodrigo and Rosenquist state (*Anaesthesia* 1988; **43:** 369–75). Our own studies in Glasgow began in 1985 after others[1] and our results are published.[2,3]

There is a problem with the assessment technique used by Rodrigo and Rosenquist because they use the same patients as controls for the administration of the different techniques. It has been shown that patients tend to prefer the later techniques in these circumstances[4] because they become more confident in the staff and less anxious with each attendance. Rodrigo and Rosenquist do not indicate in their analysis if they took account of this aspect.

Readers of their paper might assume that the use of a fixed concentration of 0.5% isoflurane is ideal for dental sedation. This technique facilitated the design of their trial, but in clinical use it is preferable to start inhalation with a low concentration such as 0.2% and increase to that concentration which gives appropriate sedation while patient contact is maintained. In practice, the final concentrations at the vaporizer can vary greatly, from 0.4% to 1.2% depending upon the patient and the extent of the dilution with air which is inevitable with a dental mask technique. The odour of isoflurane is usually not noticed or is found to be pleasant when inhalation is started with a low concentration.

Despite these reservations Drs Rodrigo and Rosenquist are congratulated on an interesting study.

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References

1. MCLEOD DD, RAMAYYA GP, TUNSTALL ME. Self-administered isoflurane in labour. A comparative study with Entonox. *Anaesthesia* 1985; **40:** 424–6.
2. PARBROOK GD, JAMES J, BRAID DP. Inhalational sedation with isoflurane: an alternative to nitrous oxide sedation in dentistry. *British Dental Journal* 1987; **163:** 88–92.
3. MCMENEMIN IM, PARBROOK GD. Comparison of the effects of subanaesthetic concentrations of isoflurane or nitrous oxide in volunteers. *British Journal of Anaesthesia* 1988; **60:** 56–63.
4. ROBERTS GJ, GIBSON A, PORTER J, DE ZOYSA S. Relative analgesia. An evaluation of the efficacy and safety. *British Dental Journal* 1979; **146:** 177–82.

A reply

Thank you for giving me the opportunity to reply to Dr Parbrook's letter and thank him too for his useful comments.

It is true that in patient-control studies at the second visit patients may have greater confidence in the staff and become less anxious. This is why in our study randomly half of the patients had isoflurane and half had nitrous oxide sedation at the first visit and the alternative at the second visit. Thus an equal number were exposed to either method of sedation at the two visits. Of the 20 patients included in the study an equal number of patients, namely 10, said they were more relaxed in the first and second visits respectively. Of these nine preferred the sedation technique at the first visit and 11 preferred the sedation technique at the second visit. Thus there was no significant difference upon which to comment.

However, in a subsequent study to find out whether conscious sedation with midazolam had any effect on the potency or duration of a non-narcotic analgesic we found that the pain scores were significantly less after the second visit than after the first visit, independent of the technique, namely whether local anaesthesia alone or local anaesthesia supplemented with midazolam sedation was used.[1] We have commented on this finding in that study.

In our study 0.5% isoflurane was used because it could easily be compared with an equipotent concentration of nitrous oxide and provided reliable sedation when compared with oxygen. As Dr Parbrook quite rightly points out, in clinical use the concentration needed may be less and it would be preferable to start inhalation with a low concentration.

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Reference

1. Rodrigo MRC, Rosenquist JB. Does midazolam sedation in oral surgery affect the potency or duration of diflunisal? (submitted for publication).

Femoral nerve block after ilio-inguinial block

It is interesting to hear that this complication has been noted by other workers (*Anaesthesia* 1988; **43:** 805), particularly in the pain clinic setting. The authors must have considerable experience of performing such blocks but we assume that this is the first time they have observed this complication.

It is indeed possible to penetrate the iliac fascia and thus block the femoral nerve, but our technique involves injection of the local anaesthetic immediately after penetration of the aponeurosis of external oblique, so that it seems unlikely that the iliac fascia, which is at a deeper level, with two intervening muscles, could be penetrated.

Our patients were both male with fairly well developed musculature. In the case described, that of a female after hysterectomy, it is possible that inadvertent deep injection was more likely but the use of a larger volume (10 ml) of concentrated solution may have increased the chance of diffusion-related spread.

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Distractions during regional anaesthesia

Dr Allen's report on the successful use of personal radio headphones to provide distraction and relaxation during surgery under regional blockade (*Anaesthesia* 1988; **43:** 426) was interesting.

We have used a similar technique in Dundee to cover many hundred orthopaedic and plastic surgical operations under regional anaesthesia over the past few years after Van Nests's recommendation,[1] with both radio and tape cassette players. A bank of cassettes has been established in the theatre suites to cover most tastes. Traditional Scottish, Country and Western and light classical music are most popular with the older age group; young patients usually prefer to bring their own tapes to theatre with them.

However, we must not delude ourselves that this is a new technique. Gaston Labat, whose seminal textbook *Regional anesthesia. Its technic and clinical application* did more than anything to popularise regional anaesthesia worldwide in the early years, states in the section on operative care of the patient undergoing surgery under local anaesthesia,

> 'Drinks by sips and even a light smoke are allowed if operative conditions permit. In certain hospitals music is brought to the operating room either by victrola or radio. Music tends to take the patient's attention away from the operating room, if it does not divert the surgeon. The radio head-piece is the most convenient because it does not disturb the silence which is so urgently needed in the operating room. Every noise should be avoided or softened, particularly that made by throwing instruments in metal or enameled basins. Making remarks or in anyway discussing the operation is not permitted, since many a word may be erroneously interpreted and harmful suspicions may be aroused.'[2]

Sixty-six years later I doubt, with the exception of the first sentence, whether any present-day anaesthetist could better his intra-operative management of regional blockade although he might find difficulty in obtaining a victrola!

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References

1. Van Nest RL. Radio headset for use with regional anesthesia. *Anesthesiology* 1979; **50:** 275.
2. Labat G. *Regional Anesthesia. Its Technic and Clinical Application.* Philadelphia; W.B. Saunders Company 1922.

The oesophageal detector device

The device described by Dr Wee (*Anaesthesia* 1988; **43:** 27–9) to distinguish oesophageal from tracheal intubation is very ingenious. Its use in anaesthesia should be appreciated by many anaesthetists particularly because it is inexpensive, easy to use, readily available and portable.

A modified version of it, with a 20-ml Portex cannula-tipped syringe is undergoing trial in our centre. This also is very reliable and can be used in the presence of a full stomach.

It is possible, in the latter circumstance, to detect the position of the tube without ventilation of the lungs and in less than 90 seconds. This is not hazardous provided that the patient is pre-oxygenated before laryngoscopy and intubation.

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Potential hazard of Hudson facemask

Tracheal collapse was anticipated in a recent case after a thyroidectomy for thyroid carcinoma so a Portex tracheal tube fitted with its 'International 15' connector was left in place with the cuff inflated. The patient was breathing oxygen-enriched air spontaneously through a T-piece system. Transfer to another hospital, where she would have a permanent tracheostomy, was required.

A Hudson facemask manufactured by Lifecare was placed over the tracheal tube with oxygen supplied by a portable oxygen cylinder. However, in the midst of the confusion, commonly associated with a patient's transfer, the oxygen inlet connector to the Hudson facemask was disconnected, and placed over the connector of the tracheal tube by an ambulanceman. This was noticed immediately and the patient disconnected. Had this misconnexion not been spotted, it could have had dire consequences; indeed, a fatal accident occurred after a similar misconnexion in a nearby casualty department.

The oxygen inlet connector to the Hudson facemask was found to fit snugly over the connector of the Portex tracheal tube. It is, therefore, important that an anaesthetist should be present on the ward, in the lift, and in the ambulance during the transfer of similar patients. It is imperative to warn nurses working on the general wards and casualty, of the danger of this misconnexion. This risk could be avoided if the manufacturer could alter the size of the oxygen inlet connector so that it would not fit on the 'International 15' connectors. It is understood that this modification has now been made to these products.

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Anaesthesia, 1988, Volume 43, pages 908–910

Book reviews

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Applied neurophysiology—with particular reference to anaesthesia

J.A. Simpson and W. Fitch. Pp. vii + 358. Wright, 1988. £35.00.

This new textbook, written jointly by a neurologist and an anaesthetist, fills a gap in the range of books on systems physiology as applied to anaesthesia. The arrangement of the material is somewhat unusual: it is divided into five parts on the basis of functional organisation rather than on anatomical systems. The first section covers cell physiology, the neuromuscular junction and neurotransmitters, and the way individual cells make up the whole nervous system. Subsequent sections cover the afferent nervous system and higher nervous functions such as consciousness, arousal, memory and learning; interaction with the environment, including reflex activity, movement, and ocular and vestibular function; and in a particularly good final section, regulation of the internal environment, including the autonomic nervous system and short sections on the cerebral circulation and on cerebrospinal fluid.

There is an emphasis throughout the book on practical human physiology, animal physiology is mentioned only when it is necessary to make an important point of difference. It is written for anaesthetists, and the emphasis on certain aspects of the subject is appropriate. Physiology texts (particularly on neurophysiology) can be extremely dry and heavy; not so this book. It is readable and relevant to the work of anaesthetists at every stage of their professional lives. Candidates for Part II FFA will find all they require, particularly in the sections on the autonomic nervous system and the neuromuscular junction, but because of the style and presentation they will undoubtedly be tempted to read more than is strictly necessary for this examination. More senior readers will find this notoriously difficult subject presented in a way which cannot fail to interest them. It may be significant that the full title of the book does not appear on the front cover, and other specialists may therefore take down this book from the shelves; they will be amply rewarded, regardless of their interest.

A particular feature is the diagrams, which often occupy a whole page or more. Rather than use labels extensively, the captions are extremely detailed, and the serious student would be advised to take each diagram as a tutorial in itself, with careful and extended study of both figure and caption. A minor quibble is that acknowledgment of reproduction of the figures taken from other sources is given in a separate single section, so that it is not clear which illustrations are original.

It is noteworthy that, although supposedly a book on physiology, there is extensive consideration of relevant pharmacology, particularly in the sections that cover neurotransmission, and this enhances the value of the work. Measurement is relatively briefly covered; the EEG is described but the derived forms such as the cerebral function monitor and power spectrum analysis, more commonly used by specialist anaesthetists in this field, are not mentioned.

This is a superb volume which will be a reference source for all anaesthetists. Trainees will find all they require for examination purposes, and less pressed practitioners will enjoy an immensely readable book.

J.N. Hopton

Hazards and complications of anaesthesia

T.H. Taylor and E. Major. Pp. 551. Churchill Livingstone, 1987. £65.00.

Complications and hazards of anaesthesia have always been with us but the recent growth in litigation, while unfortunate for anaesthesia, should not dictate our practice; we should tailor our anaesthetic cloth to our patients' needs and not to the legal skeleton. Clearly this book has been written with medicolegal issues in mind, and Dr Wylie's foreword, the editor's preface and the first chapter all mention the increasing legal problems anaesthetists face, and the last chapter on legal aspects of anaesthesia is a final reminder of our vulnerability.

This large book has been divided almost arbitrarily into sections which deal with the patient's physical status, surgical factors, drugs, procedures and equipment. Inevitably in a multi-author book there is some overlap, such as airway problems, awareness, intravenous therapy and specific drugs, but a useful index is provided with good cross referencing.

One of the strengths of the book is that many of the authors are fulltime clinical anaesthetists who, one presumes, have been persuaded to 'write what he knows and no more'. One consequence of this policy is a rather too varied bibliography at the end of the chapters: the number of references provided varies from 3 to over 150. A few authors have provided a shortlist of further reading material which is usually secondary literature in the form of reviews. It may be that this type of bibliography is more appropriate than lists of primary papers which will only rarely be consulted by the average reader.

The book is well laid out and diagrams, tables and other illustrations are of good clarity. Naturally, individual authors' styles differ considerably but the editing has successfully achieved a cohesion, which makes for easy reading. It is well bound and printed on good quality paper.

The book contains a vast amount of highly relevant information for all anaesthetists, and it should be read widely by young and old alike.

F.R. Ellis

Preanaesthetic assessment 1.

Edited by E.A.M. Frost. Pp. xiv + 305. Birkhäuser Boston Inc., 1988. £34.50.

The obvious need to keep up-to-date in medicine is enforced in the United States by practitioners there having to demonstrate that they are continuously re-educating themselves and for this they receive Continuing Medical Education (CME) credits. No CME credits means no job. And so an industry has grown up around providing for this CME requirement; there are meetings, workshops of various types and what are, in effect, correspondence courses. This book is largely a byproduct of the latter or so it says in the Foreword which is written by the Director of CME at Albert Einstein College of Medicine in New York where much of the book's material originates. Anyone thinking of buying this book would do well to read this Foreword, as well as the Editor's Introduction, which in ways it would be insensitive to summarise here, tell the intended purchaser much more about the content and style of the book than I could ever do in a 500-word review.

Reading these bits at the front will also dispel any notion that this is a comprehensive account of pre-anaesthetic assessment. It is 26 assorted essays on topics that range from renal transplantation to obesity, head injury and snakebite. It would be just as appropriately titled 'Some difficult cases you may come across'. The essays are preceded by a Case History, but these are not really integrated with the ensuing reviews and add little or nothing to the chapters as a whole. Each chapter also has a 'reviewer' (named in a footnote but not in the list of contributors at the front) although their contribution is unclear and their role is not explained anywhere; the supposition is that they have read the essays and sanctioned their contents. The chapters have all been published previously on a regular basis in an American periodical and this book is a compilation of the first 26 articles.

Many of the authors are very junior faculty members or residents and I did just wonder how much of a review could be expected from an author with only a year or so in the specialty. But I read the chapters 'blind' and only looked up the status of the contributors afterwards, and I was wrong as often as I was right in my attempts to spot the resident. Indeed the overall quality of each of the essays is good, and there are some very useful and up-to-date reviews. Self assessment questions based on each chapter are included.

The place for this book at present is in the registrar's on-call room. But at some, still to be determined, time in the future books such as this will be in the consultant's on-call call room; and between emergency cases our hero/heroine will mug up for his/her UK-style 'Continuing Proficiency' credits.

R.M. Jones

Positioning the surgical patient.

J.M. Anderton, R.I. Keen and R. Neave. Pp. vii + 116. Butterworths, 1988. £12.95.

This book is an excellent idea that does not, in my opinion, quite succeed. Each chapter covers a particular surgical position: how to move the patient safely, straps and supports, body structures at risk, anaesthetic hazards. There is a chapter on the specialised positions and, finally, a rather perfunctory chapter on the physiological effects of altering posture. Each chapter has references and there is an index. The authors are two consultant anaesthetists (with a third, Dr T.V. Campkin, adding the chapter on the sitting position) and a medical artist.

The illustrations are very good. Line drawings keep the price of a book down and reproduce well; here they work perfectly. There are some that could be improved. The illustration of the Boyle–Davis gag in tonsillectomy omits to show the tracheal tube. The figures which demonstrate the correct way to position an arm board do not illustrate that the arm should be supported at the level of the top surface of the mattress.

Unfortunately the text is not as good as the illustrations. This is partly because of the verbose style, a prejudice of this reviewer: 'particularly as tilt mechanisms are not always easy to reach and may not work properly' is preferable in my view to 'even more pertinent when it is considered that the head-down tilt mechanism on many makes of labour ward bed is not easily accessible and is inefficient in operation'. Partly it is because positioning patients is a visual process. The text contains numbered paragraphs of the anatomy at risk, with references to the figures. If some of the text were replaced by expanded, well-annotated, figures they would be effective.

The figures work particularly well in the sequences which illustrate moving an unconscious patient, sometimes connected to all manner of tubes. Again it would be more effective with text as notes alongside the diagrams, but the authors have done well to describe these manoeuvres in detail. Here is much commonsense not generally written down, and the anaesthetist who reads it will be less likely to have to learn the hard way, and have to resite an intravenous needle or two.

I would not recommend an individual anaesthetist to buy this, but it would be a valuable addition to the books in the theatre suite. Any member of the theatre personnel who moves patients would benefit from looking at it. Perhaps for the second edition ('An Atlas of Surgical Positions'?) the authors might include peridural anaesthesia, and how to deal with positioning in the X ray department and other difficult sites, such as for lithotripsy.

N.W. Goodman

Postoperative pain control.

J.I. Alexander and R.G. Hill. Pp. xi + 272. Blackwell Scientific 1987. £14.95.

It is gratifying to come across a book such as this. There are many texts now available on pain-related issues, but they tend to be rather specialised and focus on one particular aspect or method of management. This book, however, lives up to the authors' claim to be a practical users' handbook. It covers a wide range of issues, beginning with the fundamental difficulties in the assessment of objective measurement of pain, and gives a good account of the currently accepted techniques. The basic physiology of pain, the pathways involved, the myriad factors that affect its perception and its physiological consequences are all extensively covered.

A series of chapters which deal with the pharmacological aspects of opioids, nonopioids, secondary analgesics and local anaesthetics follows. The section on opioids gives a lucid account of the current state-of-the-art on opioid receptors and opioid peptides. This can be a particularly confusing area to the uninitiated, but the authors have succeeded in keeping it comprehensible without becoming too simplistic. The section which deals with each specific drug is restrained, in that the salient features that distinguish each drug are covered, without attempting to provide a pharmacology textbook. The newer opioids are mentioned, and the direction of current opiate research is indicated. Nonopioid analgesics and drugs with secondary analgesic properties are covered, again with relevant details only rather than as a complete text. The emphasis is on understanding the mode of action, rather than listing the details of bioavailability and half-life, so that the reader can make a reasoned decision about which drug to use, and consult other tomes for the finer points. Some may consider this a deficiency of the book, but it is not intended to be encylopaedic, and would otherwise run the risk of being unwieldy. The section on local anaesthetics is extremely brief, and rather inadequate for nonanaesthetic personnel.

The chapter entitled 'Choices in the management of postoperative pain' is really the crux of the book. It discusses in detail the innumerable thought processes that are involved in choosing analgesic techniques, and includes such issues as the availability of adequate nursing supervision or monitoring, of specialised equipment, and the medical condition of the patient. The arguments for systemic as against regional analgesia are presented in tabloid form. Finally, the choice of drugs and the use of drug combinations is discussed.

Regional anaesthesia and analgesia are covered in reasonable detail, but again provide little that is new to the practising anaesthetist. However, for trainees or for nonanaesthetic colleagues it provides a good review. Intraspinal opioids are covered separately, and comprehensively, to provide an excellent up-to-date account. The last section of the book deals with particular problems, such as analgesia for neonates, the morbidly obese, the elderly and daycase patients. Each chapter concludes with a brief summary that provides useful reiteration, or a quick reference for later rereading. The text is peppered with clear, simple diagrams, and a few light-hearted cartoons.

This book achieves well what the authors have set out to do. It is aimed specifically at a wide readership, and does not attempt to play the role of a reference work. However, its clearly laid out tables provide rapid access to essential clinical information, and the text provides more than enough information to enable a rational and reasoned decision to be made about almost any clinical situation. It is recommended to all those who have, or are developing, an interest in improving the standard of postoperative pain relief in their own daily practice.

S.M. Szekely

The patient's dilemma

Sir Cecil Clothier. Pp. 62. Nuffield Provincial Hospitals Trust, London, 1988. £6.00.

When a lawyer writes about medical practice, doctors usually take note. When that lawyer has also occupied the position of Health Service Commissioner (Ombudsman) it is natural for his writings to command attention. When that man writes from personal experience of anaesthesia, surgery and intensive care, and is an honorary member of our Association, it is natural that his treatise (*sic*) should not only be noted by the Editor in this journal but also that it should be read by all anaesthetists. The book itself is so brief that it would be invidious to say any more. Read it.

Books received

We thank the publishers for the following books, some of which will be reviewed in future issues of the journal.

Cancer surveys: pain and cancer 7
Guest editor G.W. Hanks. Pp. 222. Imperial Cancer Research Fund, Oxford University Press, 1988. £18.00.

Clinical anaesthesiology—burns and plastic surgery
Guest editor K.C. Judkins. Pp. x + 802. Baillière Tindall, 1987. £15.00.

L'infection en réanimation
Edited by B. Regnier and Ch. Brun-Buisson. Pp. xi + 272. Masson, 1988. F250.

Anaesthesia for thoracic procedures
Edited by B.E. Marshall, D.E. Longnecker and H.B. Fairley. Pp. 632. Blackwell Scientific, 1988. £72.20.

Intravenous anaesthesia, 2nd edn
J.W. Dundee and G.M. Wyant. Pp. ix + 358. Churchill Livingstone, 1988. £50.

Anaesthesia review, 5
Edited by L. Kaufman. Pp. 344. Churchill Livingstone, 1988. £17.50

Medicine for disasters
P. Baskett and R. Weller. Pp. xviii + 494. Wright, 1988. £60.00.

Respiratory emergencies
E.H. Sawicka and M.A. Branthwaite. Pp. 88. Butterworths, 1987. £7.95.

Care of the critically ill, 3rd edn
S.M. Ayres, R. Schlichtig and M.J. Sterling. Pp. xix + 425. Year Book Medical, 1988. £25.00.

Manual of anesthesia for emergency surgery
Edited by J.H. Donegan. Pp. xii + 403. Churchill Livingstone, 1987. £22.50.

Recent advances in critical care medicine, 3
Edited by I. McA. Ledingham. Pp. viii + 215. Churchill Livingstone, 1988. £29.50.

Progress in clinical and biological research, Vol. 264 Perspectives in shock research
Edited by R.F. Bond, H.R. Adams and I.H. Chaudry. Pp. xxi + 452. Alan R. Liss, 1988. $90.

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Anaesthetic literature

This section of *Anaesthetic literature* contains references taken from *Current Contents—Life Sciences* for June 1988. The Journals which may be consulted when *Anaesthetic literature* is compiled are those listed in *Current Contents—Life Sciences*, published by the Institute of Scientific Information, Philadelphia, Pennsylvania, USA.

Abdominal surgery

Motor pattern of the left colon before and after surgery for rectal cancer—possible implications in other disorders. Catchpole BN. *Gut* 1988; **29:** 624.

Catechol-O-methyltransferase activity in human and rat small intestine. Nissinen E, Tuominen R *et al. Life Sciences* 1988; **42:** 2609.

Bicarbonate (HCO_3) delivery to the gastroduodenal mucosa by the blood—its importance for mucosal integrity. Starlinger M, Schiessel R. *Gut* 1988; **29:** 647.

Effects of dopamine on intestinal vessels in anesthetized dogs. Van Kesteren R, Van Alphen MM, Charbon G. *Circulatory Shock* 1988; **25:** 41.

Pharmacology

Adrenergic drugs and their antagonists

Biochemical characterization of a new highly cardioselective beta-adrenoceptor antagonist. Gobbi M, Mennini T, Ratti E. *Journal of Pharmacy and Pharmacology* 1988; **40:** 243.

The dose in humans at which ICI 118,551 (a selective beta 2-adrenoceptor blocking agent) demonstrates blockade of beta 1-adrenoceptors. Harry JD, Norris SC *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 492.

Clinical pharmacokinetics of clonidine. Lowenthal DT, Matzek KM, Macgregor TR. *Clinical Pharmacokinetics* 1988; **14:** 287.

Alpha-adrenoceptor subclassification by classical and response-related methods: same question, different answers. McGrath J, Wilson V. *Trends in Pharmacological Sciences* 1988; **9:** 162.

Electrophysiologic effects of epinephrine in humans. Morady F, Nelson SD *et al. Journal of the American College of Cardiology* 1988; **11:** 1235.

Risk-benefits of antihypertensive drugs—beta-blockers. Prichard BNC. *Clinical and Experimental Pharmacology and Physiology* 1988; **15:** 203.

Interactions of heparin with alpha-2-adrenoceptors. Steudle V, Lubbecke F, Wizemann V. *Journal of Receptor Research* 1988; **8:** 613.

Anaesthetic agents

Speculations on the molecular nature of anesthesia. Albrecht RF, Miletich DJ. *General Pharmacology* 1988; **19:** 339.

Halothane: inhibition and activation of rat hepatic glutathione S-transferases. Ivanetich KM, Thumser AEA, Harrison G. *Biochemical Pharmacology* 1988; **37:** 1903.

Cutaneous and subcutaneous blood flow during general anaesthesia. Saumet JL, Leftheriotis G *et al. European Journal of Applied Physiology and Occupational Physiology* 1988; **57:** 601.

In vivo nuclear magnetic resonance studies of hepatic methoxyflurane metabolism. II. A reevaluation of hepatic metabolic pathways. Selinsky BS, Perlman ME, London RE. *Molecular Pharmacology* 1988; **33:** 567.

In vivo nuclear magnetic resonance studies of hepatic methoxyflurane metabolsim. I. Verification and quantitation of methoxydifluoracetate. Selinksy BS, Perlman ME, London RE. *Molecular Pharmacology* 1988; **33:** 559.

Respiratory and cardiovascular effects in relation to plasma levels of midazolam and diazepam. Sunzel M, Paalzow L *et al. British Journal of Clinical Pharmacology* 1988; **25:** 561.

Dual action of morphine on fetal breathing movements. Szeto HH, Zhu YS *et al. Journal of Pharmacology and Experimental Therapeutics* 1988; **245:** 537.

Analgesic agents

Plasma fentanyl concentrations during transdermal delivery of fentanyl to surgical patients. Duthie DJR, Rowbotham DJ *et al. British Journal of Anaesthesia* 1988; **60:** 614.

Hepatic safety of two analgesics used over the counter: ibuprofen and aspirin. Freeland GR, Northington RS. *Clinical Pharmacology and Therapeutics* 1988; **43:** 473.

Postoperative analgesia with fentanyl—pharmacokinetics and pharmacodynamics of constant-rate iv and transdermal delivery. Holley FO, Vansteennis C. *British Journal of Anaesthesia* 1988; **60:** 608.

Morphine effects on gentamicin disposition and toxicity in mice. Hurwitz A, Garty M, Ben-Zvi Z. *Drug Metabolism Reviews* 1988; **19:** 413.

Opioids in anaesthesia. Kapp W. *Acta Anaesthesiologica Scandinavica* 1988; **32** (Suppl. 87): 33.

Influence of naloxone on the postoperative analgesic and respiratory effects of buprenorphine. Lehmann KA, Reichling U, Wirtz R. *European Journal of Clinical Pharmacology* 1988; **34:** 343.

Effect of naloxone on haemodynamic responses to acute blood loss in unanaesthetized rabbits. Ludbrook J, Rutter PC. *Journal of Physiology* 1988; **400:** 1.

Effects of anaesthetic induction on myocardial function and metabolism: a comparison of fentanyl, sufentanil and alfentanil. Miller DR, Wellwood M *et al. Canadian Journal of Anaesthesia* 1988; **35** (No. 3 Part 1): 219.

Anticholinesterase activity of prolactin: correlation with analgesia. Ramaswamy S, Regunathan S, Bapna JS. *Journal of Pharmacy and Pharmacology* 1988; **40:** 306.

Pharmacokinetics of fentanyl in the elderly. Singleton MA, Rosen JI, Fisher DM. *British Journal of Anaesthesia* 1988; **60:** 619.

Influence of renal function on the elimination of morphine and morphine glucuronides. Wolff J, Bigler D *et al. European Journal of Clinical Pharmacology* 1988; **34:** 353.

Muscle relaxants

Postoperative care—antagonism of drugs used in anaesthesia—muscle relaxants. Buzello W. *Acta Anaesthesiologica Scandinavica* 1988; **32** (Suppl. 87): 25.

Reversal agents in anaesthesia. Geller E, Halpern P *et al. Acta Anaesthesiologica Scandinavica* 1988; **32** (Suppl. 87): 28.

The collator of this section is Dr L. Kaufman, MD, FFARCS, Anaesthetic Office, The Rayne Institute, University College, University Street, London WC1E 6JJ. Dr Kaufman is prepared to provide on request a new additional service to our readers. References from January 1984 have been entered on data base using Dbase III Plus (MsDos) and this will be upgraded in the near future to Dbase IV. The program which provides search facilities will be available free of charge save for the cost of the disk. In addition, all the data on a yearly or monthly basis will be available at a modest charge. Enquiries direct to Dr Kaufman at the above address please.

Maximal thymectomy for myasthenia gravis—Results. Jaretzki A, Penn AS *et al. Journal of Thoracic and Cardiovascular Surgery* 1988; **95:** 747.

Mivacurium chloride-induced neuromuscular blockade during nitrous oxide-isoflurane and nitrous oxide-narcotic anesthesia in adult surgical patients. Weber s, brandom BW *et al. Anesthesia and Analgesia* 1988; **67:** 495.

Other drugs

Human drug metabolism *in vitro*. Beaune PH, Guengerich FP. *Pharmacology and Therapeutics* 1988; **37:** 193.

Evaluation of the biological effects of low-molecular-weight heparins. Bender N, Seidl C *et al. Haemostasis* 1988; **18** (Suppl. 3): 23.

Rimantadine pharmacokinetics in healthy subjects and patients with end-stage renal failure. Capparelli EV, Stevens RC *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 536.

Effects of zolantidine—a brain-penetrating H2-receptor antagonist, on naloxone-sensitive and naloxone-resistant analgesia. Gogas KR, Hough LB. *Neuropharmacology* 1988; **27:** 357.

Therapeutic effects of somatostatin analogs. Lamberts SWJ. *ISI Atlas of Science-Pharmacology* 1988; **2:** 179.

Drug distribution in the body. Leblanc P-P. *General Pharmacology* 1988; **19:** 357.

Dale's principle and the one neuron-one transmitter concept. Otsuka M. *Folia Pharmacologica Japonica* 1988; **91:** 335.

Experimental evaluation of haloalkanes and liver injury. Plaa GL. *Fundamental and Applied Toxicology* 1988; **10:** 563.

Characterisation of theophylline metabolism by human liver microsomes—inhibition and immunochemical studies. Robson RA, Miners JO *et al. Biochemical Pharmacology* 1988; **37:** 1651.

Apparatus

Failure of simple clinical measurements to predict perfusion status after intravenous thrombolysis. Califf RM, O'Neil W *et al. Annals of Internal Medicine* 1988; **108:** 658.

Automatic defibrillators. Leading Article *Lancet* 1988; **1:** 1199.

Critical incidents detected by pulse oximetry during anaesthesia. McKay WPS, Noble WH. *Canadian Journal of Anaesthesia* 1988; **35** (No. 3 Part 1): 265.

Can transcutaneous electrical nerve stimulation be safely used in patients with permanent cardiac pacemakers? Rasmussen MJ, Hayes DL *et al. Mayo Clinic Proceedings* 1988; **63:** 443.

Complications

Myelopathy after the intrathecal administration of hypertonic saline. Kim RC, Porter RW *et al. Neurosurgery* 1988; **22:** 942.

Diaphragm disease—pathology of disease of the small intestine induced by non-steroidal anti-inflammatory drugs. Lang J, Price AB *et al. Journal of Clinical Pathology* 1988; **41:** 516.

General Interest

Primary brainstem death—a clinico-pathological study. Ogata J, Imakita M *et al. Journal of Neurology, Neurosurgery and Psychiatry* 1988; **51:** 646.

Long-term results in 64 patients operated upon for pheochromocytoma. Stenstrom G, Ernest I, Tisell L-E. *Acta Medica Scandinavica* 1988; **223:** 345.

Also, poor Trendelenburg and his position! A critique of its uses and effectiveness. Wilcox S, Vandam LD. *Anesthesia and Analgesia* 1988; **67:** 574.

Spinal opioids

Itching after epidural and spinal opiates. Ballantyne JC, Loach AB, Carr DB. *Pain* 1988; **33:** 149.

Effects of intrathecal fentanyl and lidocaine on somatosensory-evoked potentials, the H-reflex, and clinical response. Chabal C, Jacobson L, Little J. *Anesthesia and Analgesia* 1988; **67:** 509.

Comparison of continuous epidural infusion of fentanyl-bupivacaine and morphine-bupivacaine in management of postoperative pain. Fischer RL, Lubenow TR *et al. Anesthesia and Analgesia* 1988; **67:** 559.

Intrathecal morphine in the management of pain following cardiac surgery—a comparison with morphine i.v. Fitzpatrick GJ, Moriarty DC. *British Journal of Anaesthesia* 1988; **60:** 639.

Multiple mu opiate receptors. Pasternak GW. *ISI Atlas of Science -Pharmacology* 1988; **2:** 148.

The molecular basis of opioid receptor function. Simonds WF. *Endocrine Reviews* 1988; **9:** 200.

Intrathecal morphine and clonidine—antinociceptive tolerance and cross-tolerance and effects on blood pressure. Solomon RE, Gebhart GF. *Journal of Pharmacology and Experimental Therapeutics* 1988; **245:** 444.

Obstetric anaesthesia and analgesia

Effect of low dose heparin on blood loss at caesarean section. Hill NCW, Hill JG *et al. British Medical Journal* 1988; **296:** 1505.

Endocrine basis for the initiation, maintenance and termination of pregnancy in humans. Itskovitz J, Hodgen GD. *Psychoneuroendocrinology* 1988; **13:** 155.

Neural basis of maternal behaviour in the rat. Numan M. *Psychoneuroendocrinology* 1988; **13:** 47.

Resuscitation in late pregnancy. Rees GAD, Willis BA. *Anaesthesia* 1988; **43:** 347.

Metoclopramide pharmacokinetics in pregnant and nonpregnant sheep. Riggs KW, Axelson JE *et al. Journal of Pharmaceutical Sciences* 1988; **77:** 373.

Psychoneuroendocrine aspects of material behaviour. Rosenblatt JS, *Psychoneuroendocrinology* 1988; **13:** 3.

Effect of the addition of adrenaline to extradural diamorphine analgesia after caesarean section. Semple AJ, Macrae DJ *et al. British Journal of Anaesthesia* 1988; **60:** 632.

Comparison of extradural buprenorphine and extradural morphine after caesarean section. Simpson KH, Madej TH *et al. British Journal of Anaesthesia* 1988; **60:** 627.

A comparitive study of continuous and intermittent epidural analgesia for labour and delivery. Smedstad KG, Morison DH. *Canadian Journal of Anaesthesia* 1988; **35** (No. 3 Part 1): 234.

Paediatric anaesthesia and intensive care

Principles of drug biodisposition in the neonate: a critical evaluation of the pharmacokinetic-pharmacodynamic interface (part II). Besunder JB, Reed MD, Blumer JL. *Clinical Pharmacokinetics* 1988; **14:** 261.

Magnesium therapy in infants with postneonatal apnea. Caddell JL. *Magnesium* 1988; **7:** 103.

Fetal heart rate response to maternal exertion. Carpenter MW, Sady SP *et al. Journal of the American Medical Association* 1988; **259:** 3006.

Passive compliance of total respiratory system in preterm newborn infants with respiratory distress syndrome. Dreizzen E, Migdal M *et al. Journal of Pediatrics* 1988; **112:** 778.

Controversy on study of magnesium in apnea neonatorum. Editorial. *Journal of the American College of Nutrition* 1988; **7:** 183.

Clinically unsuspected hypoxia during sleep and feeding in infants with bronchopulmonary dysplasia. Garg M, Kurzner SI *et al. Pediatrics* 1988; **81:** 635.

Posterior cricoarytenoid and diaphragm activities during tidal breathing in neonates. Kosch PC, Hutchison AA *et al. Journal of Applied Physiology* 1988; **64:** 1968.

Hyperinflation of the lungs in infants with large left-to-right shunts. Markowitz RI, Johnson KM, Weinstein E. *Investigative Radiology* 1988; **23:** 354.

Increasing arterial carbon dioxide tension—influence on transcutaneous carbon dioxide tension measurements. Martin RJ, Beoglos A *et al. Pediatrics* 1988; **81:** 684.

Renal function and fluid therapy in high risk infants. Oh W. *Biology of the Neonate* 1988; **53:** 230.

Paediatric anaesthetists' perceptions of neonatal and infant pain. Purcell-Jones G, Dormon F, Sumner E. *Pain* 1988; **33:** 181.

Renal response to vasopressin in premature infants: what is new? Sulyok E. *Biology of the Neonate* 1988; **53:** 212.

Differential effects of CO_2 and hypoxia on bronchomotor tone in the newborn dog. Waldron MA, Fisher JT. *Respiration Physiology* 1988; **72:** 271.

Cardiovascular system

Physiology

Role of atriopeptin in blood pressure regulation. Blaine EH. *American Journal of Medical Sciences* 1988; **295:** 293.

Atrial natriuretic factor in human pathophysiology. Crozier IG, Richards AM *et al. Clinical and Experimental Pharmacology and Physiology* 1988; **15:** 173.

Effects of volume expansion and contraction on plasma levels of atrial natriuretic peptide in man. Finn WL, Gordon RD *et al. Clinical and Experimental Pharmacology and Physiology* 1988; **15:** 311.

The physiologic role of atrial natriuretic peptide in acute volume expansion. Fried TA, Stein JH. In: Brenner BM, Laragh JH, eds. *Advances in atrial peptide research.* New York: Raven Press; 1988: 101.

The atrial natriuretic factor in hypertension. Genest J. *Mayo Clinic Proceedings* 1988; **63:** 514.

The atrial natriuretic factor in hypertension. Genest J, Larochelle P *et al. American Journal of Medical Sciences* 1988; **295:** 299.

Coronary flow reserve: Physiologically important, operatively altered, and clinically emerging. Hendrick B, Barner MD. *Annals of Thoracic Surgery* 1988; **45:** 469.

The effect of atrial natriuretic peptide on acid-base balance in rats with chronic renal failure. Kusaka M, Atarashi K *et al. Life Sciences* 1988; **42:** 2577.

Physiological role of atrial natriuretic factor receptors. Maack T, Almeida FA *et al.* In: Brenner BM, Laragh JH eds. *Advances in atrial peptide research.* New York: Raven Press, 1988: 25.

The effects of acute ischemia on the isovolumic index. McGillem MJ, Deboe SF, Mancini GBJ. *American Heart Journal* 1988; **115:** 978.

Effects of caffeine on blood pressure. Myers MG. *Archives of Internal Medicine* 1988; **148:** 1189.

Depressed left ventricular performance—Response to volume infusion in patients with sepsis and septic shock. Ognibene FP, Parker MM *et al. Chest* 1988; **93:** 903.

Cardiovascular effects of conventional positive pressure ventilation and airway pressure release ventilation. Rasanen J, Downs JB, Stock MC. *Chest* 1988; **93:** 911.

Effect of positive end-expiratory pressure on right ventricular performance. Importance of baseline right ventricular function. Schulman DS, Biondi JW *et al. American Journal of Medicine* 1988; **84:** 57.

Endorphins and pain perception in silent myocardial ischemia. Sheps DS, Hinderliter A *et al. American Journal of Cardiology* 1988; **61:** 3F.

Release of atrial natriuretic peptide—physical stretch or central reflex. Sonnenberg H. In: Brenner BM, Laragh JH eds. *Advances in atrial peptide research,* New York: Raven Press, 1988: 85.

Response of atrial natriuretic peptide to adrenaline and noradrenaline infusion in man. Tunny TJ, Bachmann AW, Gordon RD. *Clinical and Experimental Pharmacology and Physiology* 1988; **15:** 299.

Reduction of atrial natriuretic factor circulating levels by endogenous sympathetic activation in hypertensive patients. Volpe M, DeLuca N *et al. Circulation* 1988; **77:** 997.

Glucocorticoid and mineralcorticoid stimulation of atrial natriuretic peptide release in man. Weidmann P, Matter DR *et al. Journal of Clinical Endocrinology and Metabolism* 1988; **66:** 1233.

Cardiovascular system

Treatment and medication

Plasminogen activators and thrombolytic therapy. Collen D. *ISI Atlas of Science-Pharmacology* 1988; **2:** 116.

ACE inhibition for the failing heart: experience with captopril. Faxon DP. *American Heart Journal* 1988; **115:** 1085.

Beneficial effects of endotracheal extubation on ventricular performance—Implications for early extubation after cardiac operations. Gall SA, Olsen CO *et al. Journal of Thoracic and cardiovascular Surgery* 1988; **95:** 819.

Effects of antihypertensive drugs on cardiovascular risk factors. Howes LG, Louis WJ. *Clinical and Experimental Pharmacology and Physiology* 1988; **15:** 199.

Myocardial preservation during ischemia and reperfusion. Ip JH, Levin RI. *American Heart Journal* 1988; **115:** 1094.

Ventricular arrhythmias. Kavanagh KM, Wyse DG. *Canadian Medical Association Journal* 1988; **138:** 903.

Successful resuscitation from cardiac arrest using high-dose epinephrine therapy. Koscove EM, Paradis NA. *Journal of the American Medical Association* 1988; **259:** 3031.

Thrombolytic therapy: current status (first of two parts). Marder VJ, Sherry S. *New England Journal of Medicine* 1988; **318:** 1512.

Effect of cardiac index and hematocrit changes on oxygen consumption in resuscitated patients. McCormick M, Feustel PJ *et al. Journal of Surgical Research* 1988; **44:** 499.

Comparison of the effects of dopamine, dobutamine, and dopexamine upon renal blood flow: a study in normal healthy volunteers. Mousdale S, Clyburn PA *et al. British Journal of Clinical Pharmacology* 1988; **25:** 555.

A physiologic comparison of external cardiac massage techniques. Newton JR, Glower DD *et al. Journal of Thoracic and cardiovascular Surgery* 1988; **95:** 892.

Intravenous volume replacement: indications and choices. Ramsey G. *British Medical Journal* 1988; **296:** 1422.

Atrial natriuretic peptide in congestive heart failure: postural changes and reset with chronic captopril therapy. Rouleau J-L, Bichet D, Kortas C. *American Heart Journal* 1988; **115:** 1060.

Effects of lidocaine and procainamide on normal and abnormal intraventricular electrograms during sinus rhythm. Schmitt CG, Kadish AH *et al. Circulation* 1988; **77:** 1030.

Propafenone: a new antiarrhythmic agent. Somberg JC, Tepper D, Landau S. *American Heart Journal* 1988; **115:** 1274.

The effect of glucose priming solutions in diabetic patients undergoing coronary artery bypass grafting. Stephens JW, Krause AH *et al. Annals of Thoracic Surgery* 1988; **45:** 544.

New cardiotonic agents—a promising approach for treatment of heart failure. Wetzel B, Hauel N. *Trends in Pharmacological Sciences* 1988; **9:** 166.

Diuretic and natriuretic effects of nifedipine in healthy persons. Wetzels JFM, Wiltink PG *et al. British Journal of Clinical Pharmacology* 1988; **25:** 547.

Respiration

Physiology

Relationships of oxygen uptake and oxygen delivery in respiratory failure not due to the adult respiratory distress syndrome. Dorinsky PM, Costello JL, Gadek JE. *Chest* 1988; **93:** 1013.

Arachidonic acid metabolism in respiratory epithelial cells. Eling TE, Henke D, Danilowicz R. *General Pharmacology* 1988; **19:** 313.

Characteristics of the upper airway pressure-flow relationship during sleep. Hudgel DW, Hendricks C, Hamilton HB. *Journal of Applied Physiology* 1988; **64:** 1930.

Nonadrenergic bronchodilator mechanisms in normal human subjects *in vivo.* Lammers JWJ, Minette P *et al. Journal of Applied Physiology* 1988; **64:** 1817.

Endogenous regulation of bronchomotor tone. Leff AR. *American Review of Respiratory Disease* 1988; **137:** 1198.

Pressure, flow, and density relationships in airway models during constant-flow ventilation. Nahum A, Sznajder JI *et al. Journal Applied Physiology* 1988; **64:** 2066.

Diffusion-dependent contribution to the slope of the alveolar plateau. Paiva M, Verbanck S, van Muylem A. *Respiratory Physiology* 1988; **72:** 257.

Assessment of maximal expiratory pressure in healthy adults. Rubinstein I, Slutsky AS *et al. Journal of Applied Physiology* 1988; **64:** 2215.

Diaphragmatic energetics and blood flow during pulmonary edema and hypotension. Rutledge FS, Hussain SN *et al. Journal of Applied Physiology* 1988; **64:** 1908.

Modulation by endogenous opioids of pulmonary vasoconstrictor response to acute lung injury. Scardella AT, Neubauer JA *et al. Journal of Applied Physiology* 1988; **64:** 1823.

Effect of pulmonary arterial $P\text{CO}_2$ on breathing pattern. Schertel ER, Schneider DA *et al. Journal of Applied Physiology* 1988; **64:** 1844.

Effects of airway anesthesia on ventilatory responses to graded dead spaces and CO_2. Shindoh C, Hida W *et al. Journal of Applied Physiology* 1988; **64:** 1885.

Plasma elevations of histamine and a prostaglandin metabolite in acute asthma. Skoner DP, Page R *et al. American Review of Respiratory Disease* 1988; **137:** 1009.

Mechanism of platelet activating factor-induced bronchoconstriction in humans. Smith LJ, Rubin AHE, Patterson R. *American Review of Respiratory Disease* 1988; **137:** 1015.

Effects of respiratory variables on regional gas transport during high-frequency ventilation. Venegas JG, Yamade Y *et al. Journal of Applied Physiology* 1988; **64:** 2108.

Gas exchange and intrapulmonary distribution of ventilation during continuous-flow ventilation. Vettermann J, Brusasco V, Rehder K. *Journal of Applied Physiology* 1988; **64:** 1864.

Respiration

Treatment and medication

Prazosin in the treatment of chronic asthma. Baudouin SV, Aitman TJ, Johnson AJ. *Thorax* 1988; **43:** 385.

Control of nocturnal hypoventilation by nasal intermittent positive pressure ventilation. Carroll N, Branthwaite MA. *Thorax* 1988; **43:** 349.

Nosocomial infection and fatality in medical and surgical intensive care unit patients. Craven DE, Kunches LM *et al. Archives of Internal Medicine* 1988; **148:** 1161.

High inflation pressure pulmonary edema—respective effects of high airway pressure, high tidal volume, and positive end-expiratory pressure. Dreyfuss D, Soler P *et al. American Review of Respiratory Disease* 1988; **137:** 1159.

Lung volume maintenance prevents lung injury during high frequency oscillatory ventilation in sufactant-deficient rabbits. McCulloch PR, Forkert PG, Forese AB. *American Review of Respiratory Disease* 1988; **137:** 1185.

Effects of dipyridamole on the hypoxemic pulmonary hypertension of patients with chronic obstructive pulmonary disease. Nenci GG, Berrettini M *et al. Respiration* 1988; **53:** 13.

High frequency, high volume ventilation for right ventricular assist. Serra J, McNicholas KW *et al. Chest* 1988; **93;** 1035.

Perioperative respiratory therapy (PORT)—A program of preoperative risk assessment and individualized postoperative care. Torrington KG, Henderson CJ. *Chest* 1988; **93:** 946.

Minimal positive end-expiratory pressure (PEEP) may be best PEEP. Tuman KJ, Braverman B, *et al. Chest* 1988; **93:** 1020.

Central nervous system

Physiology

Effect of lumbar puncture on flow of cerebrospinal fluid. Lipman B, Palmer D *et al. Investigative Radiology* 1988; **23:** 354.

Reversible reproductive dysfunction in men with obstructive sleep apnoea. Santamaria JD, Prior JC, Fleetham JA. *Clinical Endocrinology* 1988; **28:** 461.

Treatment and medication

Vascular effects of calcium antagonists. Uses in some cerebrovascular disorders. Marin J. *General Pharmacology* 1988; **19:** 295.

Endocrine and metabolic

Physiology

Role of vasopressin in regulation of sodium excretion. Cowley AW, Merrill DC *et al. American Journal of Medical Sciences* 1988; **295:** 308.

Osmotically released vasopressin augments cardiopulmonary reflex inhibition. Hasser EM, Dicarlo SE *et al. American Journal of Physiology* 1988; **254** (No. 5 Part 2): R815.

Peptide hormones and the regulation of sodium excretion. Humphreys MH, Lin SY. *Hypertension* 1988; **11:** 397.

Enhanced vasopressin (V2-receptor)-induced sodium retention in mineralocorticoid hypertension. Jeffries WB, Wang Y, Pettinger WA. *American Journal of Physiology* 1988; **254** (No. 5 Part 2): F739.

Effects of age on metabolic responses to acute and chronic stress. Odio MR, Brodish A. *American Journal of Physiology* 1988; **254** (No. 5 Part 1): E617.

Impaired neurogenic vascular response in patients with diabetes and neuropathic foot lesions. Parkhouse N, Le Quesne PM. *New England Journal of Medicine* 1988; **318:** 1306.

Endogenous opioids inhibit oxytocin release during nicotine-stimulated secretion of vasopressin in man. Seckl JR, Johnson M *et al. Clinical Endocrinology* 1988; **28:** 509.

Vasopressin—sexual dimorphism in secretion, cardiovascular actions, and hypertension. Share L, Crofton JT, Ouchi Y. *American Journal of Medical Sciences* 1988; **295:** 314.

Diabetic hyperosmolar non-ketotic decompensation. Small M, Alzaid A, MacCuish AC. *Quarterly Journal of Medicine* 1988; **66:** 251.

Renal effects of atrial natriuretic factor. Sonnenberg H. *ISI Atlas of Science-Pharmacology* 1988; **2:** 171.

Renal vasodepressor mechanism—characterization by chemical medullectomy. Swales JD, Bing RF *et al. American Journal of Medical Sciences* 1988; **295:** 241.

Second messengers identified for insulin? Walaas SI, Walaas O. *Trends in pharmacological Sciences* 1988; **9:** 151.

Role of endogenous arginine vasopressin in potentiating corticotropin-releasing hormone-stimulated corticotropin secretion in man. Watabe T, Tanaka K *et al. Journal of Clinical Endocrinology and Metabolism* 1988; **66:** 1132.

Comparison of midazolam and diazepam for sedation during plastic surgery. White PF, Vasconez LO *et al. Plastic and Reconstructive Surgery* 1988; **81:** 703.

Treatment and medication

Furosemide pharmacokinetics and pharmacodynamics in renal transplantation. Gehr TWB, Sica DA *et al. Clinical Pharmacology and Therapeutics* 1988; **43:** 547.

Loop diuretics. Greger R, Wangemann P. *Renal Physiology* 1987; **10:** 174.

Osmotic diuresis. Lang F. *Renal Physiology* 1987; **10:** 160.

The effect of low-dose naloxone infusion on plasma ACTH and LH in patients with Cushing's and Addison's diseases. Moreira AC, Foss MC *et al. Hormone and Metabolic Research* 1988; **20:** 230.

Insulin action is normalized in newly diagnosed type-1 diabetic patients after 3 months of insulin treatment. Nijs HGT, Radder JK *et al. Metabolism* 1988; **37:** 473.

Metabolic intervention in surgical patients–The effect of alpha-blockade or beta-blockade on glucose and protein metabolism in surgical patients. Shaw JHF, Holdaway CM, Humberstone DA. *Surgery* 1988; **103:** 520.

The effect of diuretic therapy on adrenaline-induced hypokalaemia and hypomagnesaemia. Whyte KF, Whitesmith R, Reid JL. *European Journal of Clinical Pharmacology* 1988; **34:** 333.

Pain

Physiology

Sources of variability in the sensation of pain. Fields HL. *Pain* 1988; **33:** 195.

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International congress calendar

1988

1 October. Pavia. *National Congress Cocieta Italiana di Anest, Rianimazione e Terapia Intensiva.*
Information: Dr G. Conti, SIARRTI, Universita degli Studi, La Sapienza di Roma, Viale del Policlinico, 00161 Roma, Italy.

6–9 October. Belgrade. *Anglo-Serbian Days of Anaesthesia.*
Information: Professor Dr D. Vucovic, Macvanska 8, 11000 Beograd, Yugoslavia.

7–8 October. Seoul. *33rd Annual National Congress of Korean Society of Anaesthesiologists.*
Information: Dr Ch Kang-Hee, Room 607, Korean Medical School, Seoul 140-00, Korea.

8–12 October. San Francisco. *Annual Meeting of the American Society of Anesthesiologists.*
Information: John W. Andes, Executive Secretary, 515 Busse Highway, Park Ridge Illinois. 60068, USA.

12–15 October. Mainz, Federal Republic of Germany. *7th Annual Meeting of the European Society of Regional Anaesthesia.*
Information: Klinikum fur Anasthesiologie, Postfach 3960, Langenbeckstrasse 1, 6500 Mainz, Federal Republic of Germany.

23–28 October. Rio de Janeiro. *World Congress of Gynecology and Obstetrics.*
Information: Professor Paulo Belfort, Av. Armando Lombardi, 800/223 Barra da Tijuca, 22600 Rio de Janeiro, Brazil.

24–28 October. Brisbane. *2nd International Conference on Emergency Medicine.*
Information: Conference Secretariat, P.O. Box 731, Toowong QLD 4066, Australia.

28–31 October. Coquimbo. *XVI Congreso Sociedad de Anestesiologia de Chile.*
Information: Dr Stella Mattig, Avda Providencia 1476, Depo 405 Santiago, Chile.

29 October–2 November. Ballarat, Victoria. *Annual General Meeting Australian Society of Anaesthetists.*
Information: The Secretariat, ASA, P.O. Box 600, Edgecliff, New South Wales 2027, Australia.

6–11 November. Pendiente, Brazil. *XXXV Brazilian Congress of Anaesthesiology.*
Information: Soc. Brazilene Anest., Rua Prof. Alfredo Gomez 36, CEP-22251, Rio de Janeiro, Brazil.

9–12 November. Tauranga, New Zealand. *Conference of Anaesthetists of New Zealand.*
Information: Dr M. Hugel, Conference Secretary, Department of Anaesthetics, Tauranga Hospital, Private Bag, Tauranga, New Zealand.

21–25 November. Kuwait. *Monitoring in Anaesthesia and ICU.*
Information: Dr Khairy Naguib, P.O. Box 18373, Farwaniya Hospital, Kuwait.

22–26 November. Trieste, Italy. *3rd Postgraduate Course on Recent Advances in Anaesthesia, Pain, Intensive Care and Emergency.*
Information: Organizing Secretariat, Trieste Traduzioni Congressi, V.le XX Septembre 4, 34125 Trieste, Italy.

27 November–2 December. Belem, Para, Brazil. *XXXV Brazilian Congress of Anaesthesiology.*
Information: Congress Secretariat, Dr Rui Silva Ventura, 66030, TV. Piedade 469/104, Belem, Para, Brazil.

28 November–1 December. Dresden. *10th Kongress der Gesellschaft.*
Information: Dr K-H Pickart, Karowerstr. 11, DDR-1115, Berlin-Buch, DDR.

12 December. Utrecht. *General and Scientific Meeting, Dutch Society of Anaesthesiolgists.*
Information: Dr A.E.E. Meursing, Tafelberg 88, 3328 ST Dordrecht, Netherlands.

17–24 December. Colorado. *Current Issues in Medicine.*
Information: Professional Seminars/University of Miami, P.O. Box 012318, Miami, Florida 33101.

27–30 December. Udaipur. *XXXVII National Conference.*
Information: Dr A.M. Agnihotri, Department of Anaesthesiology, Ganghi Medical College and Hamidia Hospital, Bhopal 462 001, India.

28–30 December. Cairo. *Annual Meeting with American Universities.*
Information: Professor M.H. Shaker, P.O. Box 71, Giza, Egypt.

1989

13–14 January. London. *Winter Scientific Meeting, Association of Anaesthetists of Great Britain and Ireland.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1 3RA.

14–21 January. Puerto Vallarta, Mexico. *7th Annual Symposium of the Mount Sinai Medical Center on Clinical Update in Anesthesiology.*
Information: Helen Phillips, Mount Sinai Medical Center, 1 Gustave L. Levy Place, Box 1010, New York, NY 10029, USA.

21–24 March. Brussels. *Ninth International Symposium on Intensive Care and Emergency Medicine.*
Information: Dr J-L Vincent, Department of Intensive Care, Erasme University Hospital, Route de Lennik 808, B 1050 Brussels, Belgium.

28–31 March. Nicosia, Cyprus. *8th Congress of the Greek Society of Anaesthesiologists.*
Information: 8th Congress of Anaesthesiology, Greek Society of Anaesthesiologists, 34 Oragoumi Street, 115 28 Athens, Greece.

13–15 April. Yamaguchi City, Japan. *Annual Meeting of the Japan Society of Anesthesiology.*
Information: Dr M. Fujita, 5F TY Building, 18-11 Hongo Chome 3, Bunkyo-Ku, Tokyo 113, Japan.

7–12 May. Melbourne, Australia. *Faculty of Anaesthetists and the Royal Australasian College of Surgeons Annual General Meeting.*
Information: Administrative Officer, Faculty of Anaesthetists, RACS, Spring Street, Melbourne, Victoria 3000.

11–14 May. Rotterdam. *Second European Congress of Paediatric Anaesthesia.*
Information: Mrs J.F. Aukes-Jager, Sophia Children's Hospital, Department of Paediatric Anaesthesia, Gordelweg 160, NL-3038 GE Rotterdam.

17–19 May. Lisbon. *VIII Annual Meeting of the European Society of Regional Anaesthesia.*
Information: Dr E. Lopes Soares, Rua Cidade de Cadiz 14, 1500 Lisboa.

9–13 June. Ottawa. *Joint Meeting of the Canadian Anaesthetists' Society with the Association of Anaesthetists of Great Britain and Ireland.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

26–30 June. Copenhagen. *20th Scandinavian Congress.*
Information: Professor S.H. Johansen, Herlev Hospital, DK 2730, Herlev, Denmark.

13–15 July. London. *Refresher Course and Scientific Meeting of European Academy of Anaesthesiologists.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 2RA.

12–16 August. Christchurch. *Combined Meeting of New Zealand Society with the Australian Society of Anaesthetists.*
Information: Secretariat, ASA NZ Society of Anaesthetists, P.O. Box 600, Edgecliff, NSW 2027, Australia.

23–25 August. Oulu, Finland. *Scandinavian Meeting of the European Society of Regional Anaesthesia.*

Information: Secretariat, Scandinavian ESRA, Department of Anaesthesia, University of Oulu, SF 90220 Oulu, Finland.

1–4 September. Tunisia. *3rd Pan Arab Congress on Anaesthesia and Intensive Care.*
Information: Dr Jamal Al-Shanableh, P.O. Box 15404, Marka-Amman, Jordan.

3–8 September. Kyoto, Japan. *Fifth World Congress on Intensive and Critical Care Medicine.*
Information: The Fifth World Congress on Intensive and Critical Care Medicine, c/o Japan Convention Services Inc., Nippon Press Center Building, 2-2-1 Uchisaiwai-cho, Chiyoda-ku, Tokyo 100, Japan.

10–14 September. Freiburg. *8th Congress of European Society of Pneumology.*
Information: Professor Dr med. H. Matthys, Arztlicher Direktor, Abteilung Pneumologie, Robert-Koch-Klinik, Universitat, D 7800 Freiburg, West Germany.

10–15 September. Hong Kong. *6th World Congress on Emergency and Disaster Medicine.*
Information: Dr M. Moles, c/o Meeting Planners, 701 Tung Wai Comm. Bldg, 109 Gloucester Road, Wanchai, Hong Kong.

12–16 September. Austria. *International Conference on Anaesthesia, Intensive Care and Emergency Medicine.*
Information: Professor Dr J.M. Hackl, University Klinik fur Anaesthesie und Allg. Intensivmedizin, Anichstr. 35, A-6020 Innsbruck, Austria.

13–15 September. Swansea. *Linkman Conference and Annual Meeting of the Association of Anaesthetists of Great Britain and Ireland.*
Information: Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

14–15 September. Osaka, Japan. *4th International Symposium of Endocrinology in Anaesthesia and Surgery.*
Information: Department of Anesthesiology, University of Hirosaki, School of Medicine, 5 Zaifu-cho, Hirosaki, Aomori-ken, 036 Japan.

17–19 **September.** Beijing. *1st International Symposium on emergency Medicine.*
Information: Dr M. Moles, c/o Meeting Planners, 701 Tung Wai Comm. Bldg, 109 Gloucester Road, Wanchai, Hong Kong.

18–22 September. London. *9th Congress of the Federation Internationale de Medecine Manuelle.*
Information: Conference Associates FIMM, 27A Medway Street, London, SW1P 2BD.

27–30 September. Warsaw. *Joint Meeting between Association of Paediatric Anaesthetists of Great Britain and Ireland and Polish Society.*
Information: Dr J. Kacki, ul Kasprzaka 17A, 01-211 Warsaw, Poland.

4–7 October. Tunis. *Third Pan Arab Congress on Anaesthesia and Intensive Care.*
Information: Secretary, P.O. Box 15404, Marka, Amman, Jordan.

14–18 October. New Orleans. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, 515 Busse Highway, Park Ridge, Illinois 60068, USA.

18–20 October. Barcelona. *11th Congress of Chronical Roncopathy.*
Information: BRP, Edificio Layetana C/Pau Claris, 138, 08009, Barcelona, Spain.

5–10 November. Sao Paulo. *36th Brazilian Congress of Anesthesiology.*
Information; Congress Secretariat, Dr R.S. Nathias, Rua Caiubi 666, Sao Paulo, Brazil 05010.

11–17 November. River Rhine. *International Symposium to commemorate '60 years of surfactant research'.*
Information: Professor B. Lachmann, Department of Anesthesiology, Erasmus University, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands.

1990

24–26 February. New Orleans. *Mardi Gras Anaesthetic Course.*
Information: Alan Grogono, Tulane University Medical Center, 1430 Tulane Avenue, New Orleans, Louisiana 70112, USA.

10–14 March. Honolulu. *64th Congress of the International Anaesthesia Research Society.*
Information: Emerson A. Moffitt, IARS, 3645 Warrendsville Center Road, Cleveland, Ohio 44122, USA.

13–19 May. Wellington, New Zealand. *Faculty of Anaesthetics and the Royal Australasian College of Surgeons Annual General Meeting.*
Information: Administrative Officer, Faculty of Anaesthetists, RACS, Spring Street, Melbourne, Victoria 3000.

15–19 June. Vancouver. *47th Annual Meeting of the Canadian Anaesthetists' Society.*
Information: Ms Ann Andrews, CAS 187, Gerrard St. E, Toronto, Ontario M5A 2E5 Canada.

9–15 September. Warsaw. *VIIIth European Congress of Anaesthesiologie.*
Information: The Organising Committee, VIIIth European Congress of Anaesthesiology, c/o The Polish Society of Anaesthesiology and Intensive Therapy, ul. Kasprzaka 17a, 01-211 Warsaw, Poland.

23–28 September. Seoul. *8th Asian/Australasian Congress of Anaesthesia.*
Information: Department of Anesthesiology, Seoul National University Hospital 28 Yongun-Dong, Chongro-Ku, Seoul 110.

26–28 September. Manchester. *Linkman Conference and Annual Scientific Meeting and Exhibition.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

19–23 October. Las Vegas. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, Illinois. 60068, USA.

5–10 November. Sao Paulo. *36th Brazilian Congress of Anesthesiology.*
Information: Dr R. Mathias, Rua Caiubi 666, Sao Paulo, Brasil 05 010.

5–9 December. San Juan. *15th Caribbean Symposium in Anaesthesia and Related Fields.*
Information: Miguel Colon-Morales, GPO Box 4547, San Juan, Puerto Rico 00936.

1991

8–12 March. San Antonio. *65th Congress of the International Anesthesia Research Society.*
Information: Emerson A. Moffitt, IARS, 3645 Warrensville Center Road, Cleveland, Ohio 44122, USA.

21–25 June. Quebec City. *48th Annual Meeting of Canadian Anaesthetists' Society.*
Information: Ms Ann Andrews, CAS, 187 Gerrard St. E., Toronto, Ontario, M5A 2E5, Canada.

1992

29 March–2 April. Atlanta, Georgia. *The Third International Symposium on the History of Anaesthesia.*
Information: R.K. Calverley, Medical Center, University of California, 225 Dickinson Street, San Diego, California CA 92103, 1990, USA.

14–19 June. The Hague. *10th World Congress of Anaesthesiology.*
Information: Dr Harm Lip, Nilantsweg 99, 8041 AR Zwolle, Netherlands.

17–21 October. New Orleans. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, Illinois. 60068, USA.

1993

15–17 September. Edinburgh. *Joint Meeting with the Canadian Society of Anaesthetists.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

9–13 October. Washington, DC. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, Illinois. 60068, USA.

Anaesthesia, 1988, Volume 43, pages 917–920

Courses in Anaesthesia

The information below is believed to be accurate but those intending to attend a course should check the details with the relevant organiser. Applications and further information cannot be provided by *Anaesthesia.*

FFARCS Part 1

BIRMINGHAM Postgraduate Medical Centre, East Birmingham Hospital, Bordesley Green East, Birmingham B9 5ST	May 1989	£150	Postgraduate Secretary, Postgraduate Medical Centre, East Birmingham Hospital, Bordesley Green East, Birmingham B9 5ST
DUNDEE Ninewells Hospital and Medical School, Dundee DD1 9SY	September 1988–March 1989 Monday afternoons	NO FEE	The Secretary, Department of Anaesthesia, Ninewells Hospital and Medical School, Dundee DD1 9SY *Tel.* 0382 60111 *ext.* 2175
EDINBURGH Department of Anaesthetics, Royal Infirmary, Edinburgh EH3 9YW	Scientific basis of anaesthesia, 24–28 October 1988, 24–28 April 1989	£150	Postgraduate Dean, Edinburgh Postgraduate Board for Medicine, Pfizer Foundation, Hill Square, Edinburgh EH8 9DR *Tel.* 031 667 1011 *ext.* 4521
	Basic concepts in anaesthetic practice 9–13 January 1989		University Department of Anaesthetics, Royal Infirmary, Edinburgh EH3 9YW *Tel.* 031 229 2727
LEICESTER University Department of Anaesthesia, Leicester Royal Infirmary, Leicester LE1 5WW	Whole time revision course 16–20 January 1989	£65 NO FEE FOR DOCTORS WITHIN TRENT REGION	The Secretary, Department of Anaesthesia, Leicester Royal Infirmary, Leicester LE1 5WW
LONDON Department of Anaesthetics, St Thomas' Hospital, Lambeth Palace Road, London SE1 7EH	Friday day release 11 November–20 January 1989	£120	Department of Anaesthetics, St Thomas' Hospital, Lambeth Palace Road, London SE1 7EH
SOUTHAMPTON Southampton General Hospital	Intensive course, 12–16 December, April 1989, July 1989		Regional Postgraduate Administrator, Wessex Regional Health Authority, Highcroft, Romsey Road, Winchester SO22 5DH

FFARCS Part 2

CAMBRIDGE Addenbrooke's Hospital, Hills Road, Cambridge CB2 2QQ	One-day revision course, November and May	FEE ON APPLICATION	Ms D. Mills, Department of Anaesthetics, Addenbrooke's Hospital, Cambridge CB2 2QQ

CARDIFF University Hospital of Wales, Heath, Cardiff	23–28 January Cardiff, 30 January–4 February Bristol		Dr Neville Goodman, Department of Anaesthetics, Bristol Royal Infirmary, Bristol
	Bristol and Cardif July 1989		
	Management for Anaesthetists, July 1989		Professor M. D. Vickers, Department of Anaesthetics, University of Wales College of Medicine, Cardiff
DUNDEE Ninewells Hospital and Medical School, Dundee DD1 9SY	September 1988–March 1989, Monday afternoons (consecutively with Part 1)	NO FEE	The Secretary, Department of Anaesthesia, Ninewells Hospital and Medical School, Dundee DD1 9SY *Tel.* 0832 60111 *ext.* 2175
EDINBURGH Royal Infirmary of Edinburgh	Scientific basis of anaesthesia, 24–28 October 1988 24–28 April 1989	£150	Postgraduate Dean, Edinburgh Postgraduate Board of Medicine, Pfizer Foundation, Hill Square, Edinburgh EH8 9DR *Tel.* 031 667 1011 *ext.* 4521
LEEDS Leeds General Infirmary	Basic science course, Alternate Wednesdays, September–July	NO FEE TO THOSE EMPLOYED IN REGION	Departmental Secretary, Department of Anaesthesia, 24 Hyde Terrace, Leeds LS2 9LN *Tel.* 0532 334870
LEICESTER University Department of Anaesthesia, Leicester Royal Infirmary, Leicester LE1 5WW	4 November–28 April Friday afternoons		The Secretary, Department of Anaesthesia, Leicester Royal Infirmary, Leicester LE1 5WW
LONDON Department of Anaesthetics, St Thomas' Hospital, Lambeth Palace Road, London SE1 7EH	Day release, Fridays, 24 February–28 April	£120	Department of Anaesthetics, St Thomas' Hospital, Lambeth Palace Road, London SE1 7EH
NEWCASTLE UPON TYNE Department of Anaesthesia, Royal Victoria Infirmary, Newcastle upon Tyne	Day release, Wednesdays, 21 September–14 December	NO FEE	Professor C. J. Hull, Department of Anaesthesia, Royal Victoria Infirmary, Newcastle upon Tyne *Tel.* 091 222 6980 *ext.* 24910
SOUTHAMPTON Southampton General Hospital	Intensive course, March 1989		Regional Postgraduate Administrator, Wessex Regional Health Authority, Highcroft, Romsey Road, Winchester SO22 5DH

FFARCS Part 3

CAMBRIDGE Addenbrooke's Hospital and Papworth Hospital	3-day revision course, December and May	FEE ON APPLICATION	Ms D. Mills, Department of Anaesthetics, Addenbrooke's Hospital, Cambridge CB2 2QQ
DUNDEE Ninewells Hospital and Medical School, Dundee DD1 9SY	September 1988–March 1989, Thursday afternoons	NO FEE	The Secretary, Department of Anaesthesia, Ninewells Hospital and Medical School, Dundee DD1 9SY *Tel.* 0832 60111 *ext.* 2175
LEEDS St James's University Hospital, Leeds	Alternate Wednesdays, September–July	NO FEE FOR THOSE EMPLOYED IN REGION	Departmental Secretary, Department of Anaesthesia, 24 Hyde Terrace, Leeds LS2 9LN *Tel.* 0532 334870
LEICESTER University Department of Anaesthesia, Leicester Royal Infirmary, Leicester LE1 5WW	8–12 May 1989, Revision course	£65 NO FEE FOR DOCTORS WITHIN TRENT REGION	The Secretary, Department of Anaesthesia, Leicester Royal Infirmary, Leicester LE1 5WW
LONDON Faculty of Anaesthetists, The Royal College of Surgeons of England, 35–43 Lincoln's Inn Fields, London WC2A 3PN	3–21 April 1989, 3-week course of lectures (with tutorials in the evenings of 1st and 2nd weeks)		The Secretary, College of Anaesthetists, The Royal College of Surgeons of England, 35–43 Lincoln's Inn Fields, London WC2A 3PN
Department of Anaesthesia, The Royal Free Hospital, Pond Street, London NW3 2QG	Spring and winter, Intensive 5-day revision course	£100	The Secretary, Department of Anaesthesia, Royal Free Hospital, Pond Street, London NW3 2QG *Tel.* 01 794 0500 *ext.* 3956
MANCHESTER Manchester Royal Infirmary	14–18 November and March/April 1989		Course Secretary, Department of Postgraduate Medical Studies, Stopford Building, Oxford Road, Manchester M13 9PT
NEWCASTLE UPON TYNE Department of Anaesthesia, Royal Victoria Infirmary, Newcastle upon Tyne	4 January–15 March 5 April–28 June, Day release Wednesdays	NO FEE	Professor C. J. Hull, Department of Anaesthesia, Royal Victoria Infirmary, Newcastle upon Tyne
SOUTHAMPTON Southampton General Hospital	Day release course, 19 September–19 December, Intensive course March 1989		Regional Postgraduate Administrator, Wessex Regional Health Authority, Highcroft, Romsey Road, Winchester SO22 5DH

OTHER COURSES

CARSHALTON			
Queen Mary's Hospital for Children	Paediatric anaesthesia, 6–9 December, 28 February–3 March, 9–12 May	£100	The Secretary, Postgraduate Medical Centre, Queen Mary's Hospital for Children, Carshalton, Surrey SM5 4NR
LEEDS			
University Departments	Measurement course, 13–17 March One week full-time course on clinical measurement relevant to all three parts	FEE ON APPLICATION NO FEE FOR THOSE EMPLOYED IN REGION	The Departmental Secretary, Department of Anaesthesia, 24 Hyde Terrace, Leeds LS2 9LN *Tel.* 0532 334870
LONDON			
Faculty of Anaesthetists, The Royal College of Surgeons of England, 35–43 Lincoln's Inn Fields, London WC2A 3PN	Current topics in anaesthesia, one-week refresher course for doctors who have been engaged in anaesthetic work for some time, 19–23 June	FEE ON APPLICATION	The Secretary, College of Anaesthetists, The Royal College of Surgeons of England, 35–43 Lincoln's Inn Fields, London WC2A 3PN
Charing Cross Hospital, Fulham Palace Road, London W6 8RF	London Pain Course 15–17 May	£140	Pain Clinic Secretary, Anaesthetics Department, 13th Floor south Rm 13-05, Charing Cross Hospital, Fulham Palace Road, London W6 8RF
Queen Charlotte's Hospital for Women, Goldhawk Road, London W6 0XG	Course in obstetric anaesthesia and analgesia, 16–18 November	£125	Symposium Secretary, Queen Charlotte's Hospital for Women, Goldhawk Road, London W6 0XG

THIS PAGE CONCERNS YOU IF YOU ARE A MEDICALLY QUALIFIED ANAESTHETIST IN GREAT BRITAIN AND IRELAND, OVERSEAS OR IN TRAINING AND ARE NOT YET A MEMBER OF THE ASSOCIATION OF ANAESTHETISTS OF GREAT BRITAIN AND IRELAND OR IF YOU ARE A MEMBER OF ANOTHER PROFESSION WHO PRACTISES IN ANAESTHESIA AND YOU WISH TO APPLY FOR ASSOCIATE MEMBERSHIP

Ordinary Membership (*United Kingdom and Ireland only*)

Voting membership of the Association (the only effective body representing anaesthetists' interests in non-academic matters).

The right of attendance at the Annual General and Scientific Meetings and all other meetings of the Association of Anaesthetists.

Overseas and Associate Membership

The right of attendance at the Annual Scientific Meeting and other meetings of the Association.

Junior Membership (*United Kingdom and Ireland only*)

Voting membership of the Association.

Representation on the Council of the Association. The Chairman and Secretary of the Junior Group sit on Council as voting members.

Attendance at the Annual Scientific Meeting of the Association and at the special Annual Scientific Meeting of the Junior Anaesthetists' Group, at which Junior Members of the Association are given preference.

Membership Fees (inclusive of the journal *Anaesthesia*)

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How to apply for membership

Fill in the application form on the other side of this page.

Have it countersigned by two members of the Association, one of whom must be an Ordinary Member.

Tear out the page and send it to the address indicated overleaf.

Do not send money with your application

THE ASSOCIATION OF ANAESTHETISTS OF GREAT BRITAIN AND IRELAND

APPLICATION FOR MEMBERSHIP

to

The Association of Anaesthetists of Great Britain and Ireland
9 Bedford Square,
London WC1B 3RA, England

(This application will be considered by Council at its next meeting. NO MONEY should be sent in the meantime. After acceptance of the application by Council, the Hon. Secretary will notify the applicant of Council's decision and the amount of subscription payable in the current financial year.)

......................19

To the Honorary Secretary,
Association of Anaesthetists of Great Britain and Ireland

I (full name) .... offer my name as a candidate
BLOCK LETTERS

for (a) MEMBERSHIP (b) OVERSEAS MEMBERSHIP (c) ASSOCIATE MEMBERSHIP (d) JUNIOR MEMBERSHIP of the Association (*please delete categories not applicable*)*

I hold the following appointment(s) as an anaesthetist (*please state grade if in the National Health Service, and indicate the approximate proportion of time spent in the practice of anaesthesia*):

....

....

....

Qualifications (with dates)..

....

(Signed)...
Address..
....Hospital Tel. No:..................................
....Home Tel. No:.....................................

We, being Members† of the Association, nominate as a candidate for MEMBERSHIP/OVERSEAS/ ASSOCIATE/JUNIOR MEMBERSHIP

....

1. (Signed)...
(NAME IN BLOCK LETTERS)
Address..
BLOCK LETTERS

2. (Signed)...
(NAME IN BLOCK LETTERS)
Address..
BLOCK LETTERS

* See the reverse of this page for details of membership categories.
† One sponsor must be an Ordinary Member of the Association.

Notice to contributors to *Anaesthesia*

Manuscripts will be reviewed for possible publication on the understanding that they are being submitted to one journal at a time and have not been published, simultaneously submitted, or already accepted for publication elsewhere. This does not preclude consideration of a manuscript that has been rejected by another journal or of a complete report that follows publication of preliminary findings elsewhere, usually in the form of an abstract. Investigations performed on man must conform to appropriate ethical standards including voluntary, informed consent and acceptance by an ethical committee. Articles accepted become copyright of *Anaesthesia*.

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Dr J. N. Lunn, Editor of ***Anaesthesia****, Department of Anaesthetics, University Hospital of Wales, Heath Park, Cardiff CF4 4XW, UK.*

PREPARATION OF MANUSCRIPTS

Articles for *Anaesthesia* should be prepared in accordance with *Uniform requirements for manuscripts submitted to biomedical journals* (*British Medical Journal* 1979; **1:** 532–5) except that the titles of journals in the reference section should be given in full (see below). A reprint of these requirements of which this notice is a summary, can be obtained from the *British Medical Journal* price 50 pence (UK).

Type manuscripts on white bond paper, 20.3 × 26.7 cm or 21.6 × 27.9 cm (8 × 10½ in. or 8½ × 11 in.) or ISO A4 (212 × 297 mm) with margins of at least 2.5 cm (1 in.). Use double, and preferably triple, spacing throughout, including the references. Please do not use a dot matrix printer, particularly one with poor quality descenders or ascenders. Unseparated, fan-folded manuscripts may be returned to the author. *The manuscript* should consist of the following sections in this order each beginning on a new page: *title page*, *summary* and *key words*, *text*, *acknowledgments*, *references*, *individual tables*, and *legends for figures*.

Number pages consecutively, beginning with the title page.

THE TITLE PAGE

The name of the author and the address to which proofs and other correspondence are to be addressed should appear in the top left-hand corner of the sheet.

The main title should be restricted to five words if this is possible. It should be typed in capitals across the centre of the title page.

A subsidiary title of not more than 12 words may be supplied if this is considered to be necessary. This should be typed in lower case immediately beneath the main title.

The names of the authors should be typed IN CAPITALS across the title page immediately beneath the titles without degrees or designations. Initials should precede the surname. If there is more than one author the word 'AND' should be placed before the name of the last author.

A line should be typed across the title page below the author(s) name(s) in capitals.

The author(s) name(s), degrees and designations should be typed in lower case below the line. Initials should precede the name of each author and his degrees, without full stops between letters, and appointment (e.g. Consultant, Registrar, etc.) should follow it.

A full postal institutional address should follow the names, degrees and appointments. Correspondence will normally be addressed to the first author but, if it is desired to direct correspondence other than to the first author, or if different authors belong to different institutions or departments, a separate sentence should be added: this should start on a new line and begin 'Correspondence should be addressed to . . .' and a full postal address should follow.

SUMMARY AND KEY WORDS

Start a new sheet

The second page should carry a summary of not more than 150 words. The summary should state the purpose of the study or investigation, basic procedures, main findings and their statistical significance, and the principal conclusions.

Do not use abbreviations except for units of measurement (e.g. mg, cm, etc.).

Key (indexing) words. Below the abstract, provide and identify as such, three to 10 key words or short phrases that will assist indexers. Use terms from the Medical Subject Headings list from *Index Medicus*. The Editor may modify these at proof stage to conform with agreed practice of certain other anaesthetic journals in the English language.

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The text of observational and experimental articles, case reports, etc. is usually divided into sections with the headings *Introduction*, *Methods*, *Results* and *Discussion*. Long articles will need subheadings within some sections to clarify their content.

Letters for the correspondence pages should be double spaced and prepared in accordance with the format in a recent copy of *Anaesthesia*.

Headings: three steps of heading may be used in typescripts:

(i) CAPITALS across the centre of the page.

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(iii) Underlined words at the beginning of a paragraph. These may either be followed by a full stop or form part of the sentence of the paragraph.

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Number references consecutively in the order in which they are first mentioned in the text. Identify references in text, tables and legends by arabic numerals. References cited only in tables or in legends to figures should be numbered in accordance with a sequence established by the first identification in the text of the particular table or illustration. Use double or treble spaced typing.

Use the form of reference adopted by the US National Library of Medicine and used in *Index Medicus*. Use the style of the examples cited at the end of this section.

The titles of journals should be given in full.

Avoid using abstracts as references except those published in a recognised journal. 'Unpublished observations' and 'personal communications' may not be used as references, although references to written, not verbal, communications may be inserted (in parentheses) in the text. Include among the references manuscripts accepted but not yet published; designate the journal followed by (*in press*) in parentheses. Information from manuscripts submitted but not yet accepted should be cited in the text as (unpublished observations) in parentheses.

The references must be verified by the author(s) against the original documents.

(*continued overleaf*)

Examples of correct form of references
Note: first and last pages in all references.

JOURNAL

Standard journal article—(List all authors)
Soter NA, Wasserman SI, Austen KF. Cold urticaria: release into the circulation of histamine and eosinophil chemotactic factor of anaphylaxis during cold challenge. *New England Journal of Medicine* 1976; **294:** 687–90.

Corporate author
The Committee on Enzymes of the Scandinavian Society for Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gamma-glutamyltransferase in blood. *Scandinavian Journal of Clinical Laboratory Investigation* 1976; **36:** 119–25.
Anonymous. Epidemiology for primary health care. *International Journal of Epidemiology* 1976; **5:** 224–5.

BOOKS AND OTHER MONOGRAPHS

Personal author(s)
Osler AG. *Complement: mechanisms and functions.* New York: Prentice-Hall, 1976.

Corporate authors
American Medical Association Department of Drugs. AMA drug evaluations, 3rd edn. New York: Publishing Sciences Group, 1977.

Editor, compiler, chairman as author
Rhodes AJ, Van Rooven CE, *comps. Textbook of virology: for students and practitioners of medicine and other health sciences*, 5th edn. Baltimore: The Williams & Wilkins Co., 1968.

Chapter in book
Weinstein L, Swartz MN. Pathogenic properties of invading micro-organisms. In: Sodeman WA Jr, Sodeman WA, eds. *Pathologic physiology: mechanisms of disease.* Philadelphia: W.B. Saunders, 1974: 457–72.

Agency publication
National Center for Health Statistics. Acute conditions: incidence and associated disability, United States, July 1968—June 1969. Rockville, MD: National Center for Health Statistics, 1972. (*Vital and health statistics, Series* **10:** Data from the National Health Survey, No. 69) [DHEW publication No. (HSM) 72–1036].

OTHER ARTICLES

Newspaper article
Shaffer RA. Advances in chemistry are starting to unlock mysteries of the brain: discoveries could help to cure alcoholism and insomnia, explain mental illness. How the messengers work. *Wall Street Journal* 1977 Aug 12: 1(col 1), 10(col 1).

Magazine article
Roueche B. Annals of medicine: the Santa Claus culture. *The New Yorker* 1971 Sept 4: 66–81.

TABLES

Do not include tables in the text. Start a new sheet for each table and space the material adequately. The author(s) name(s) should appear in the top right-hand corner.
Indicate the approximate position of each table in relation to the subject matter of the text in the left-hand margin of the appropriate page on the manuscript. Do not submit tables as photographs. Number tables consecutively with arabic numerals. Supply a brief title for each. Give each column a short or abbreviated heading. Place explanatory matter in footnotes. Explain in footnotes all non-standard abbreviations that are used in each table. For footnotes, use the following symbols in this sequence: *, †, ‡, §, ||, ¶, **, ††, etc. Identify statistical measures of variations such as SD and SEM. *Legends for tables* should appear on the face of the table.

Cite each table in the text in consecutive order and mark the approximate position of the table in the left-hand margin of the text.

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Contributors are advised to study the SI *Conversion Tables* provided in the January 1978 issue of *Anaesthesia, Units, Symbols and Abbreviations* (*A Guide for Biological and Medical Editors and Authors*) published by the Royal Society of Medicine, London W1M 8AE, and *Uniform requirements for manuscripts submitted to biomedical journals* (*British Medical Journal* 1979; **1:** 532–5).

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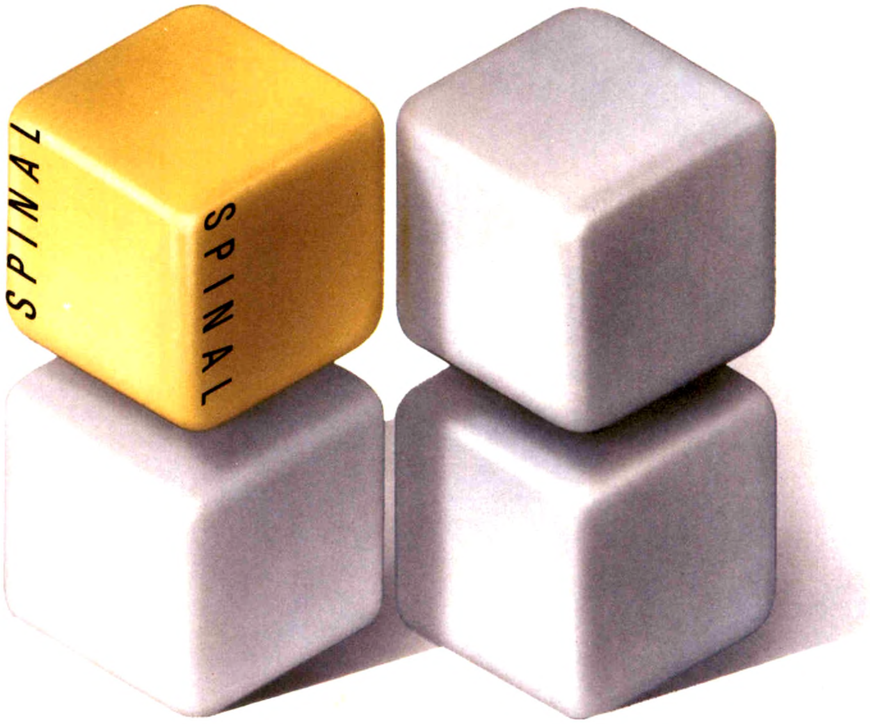

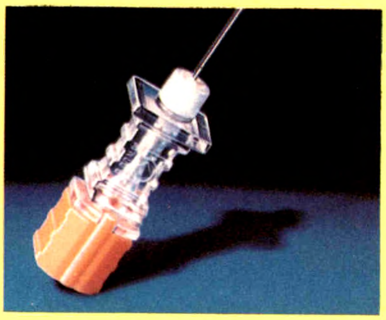

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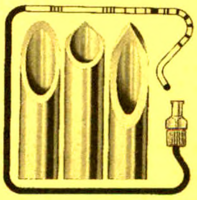

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